SEDAR 94: Florida Hogfish

Review Workshop

Florida Keys/East Florida

Christopher E. Swanson,

Heather Christiansen, and Dustin Addis

USF | FWC-FWRI Marine Fisheries Research

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Goals

- Base Model Diagnostics
  - Model convergence
  - Model consistency
  - Model validation/prediction skill
  - Sensitivity runs
- Base Model Uncertainty
  - MCMC analysis
  - Bootstrap analysis
- Stock Status Overview
  - Per-recruit analysis
  - SAFMC SSDC
- Bridge Building
  - “S37data_S94config” model
  - “S37_SRFS” model

SEDAR 94: Florida Hogfish

KEYS Base Model Diagnostics

Base Model Development

- Carvalho et al. (2021)
  - A cookbook for using model diagnostics in integrated stock assessments
- Step-by-step roadmap for development of a potential base model

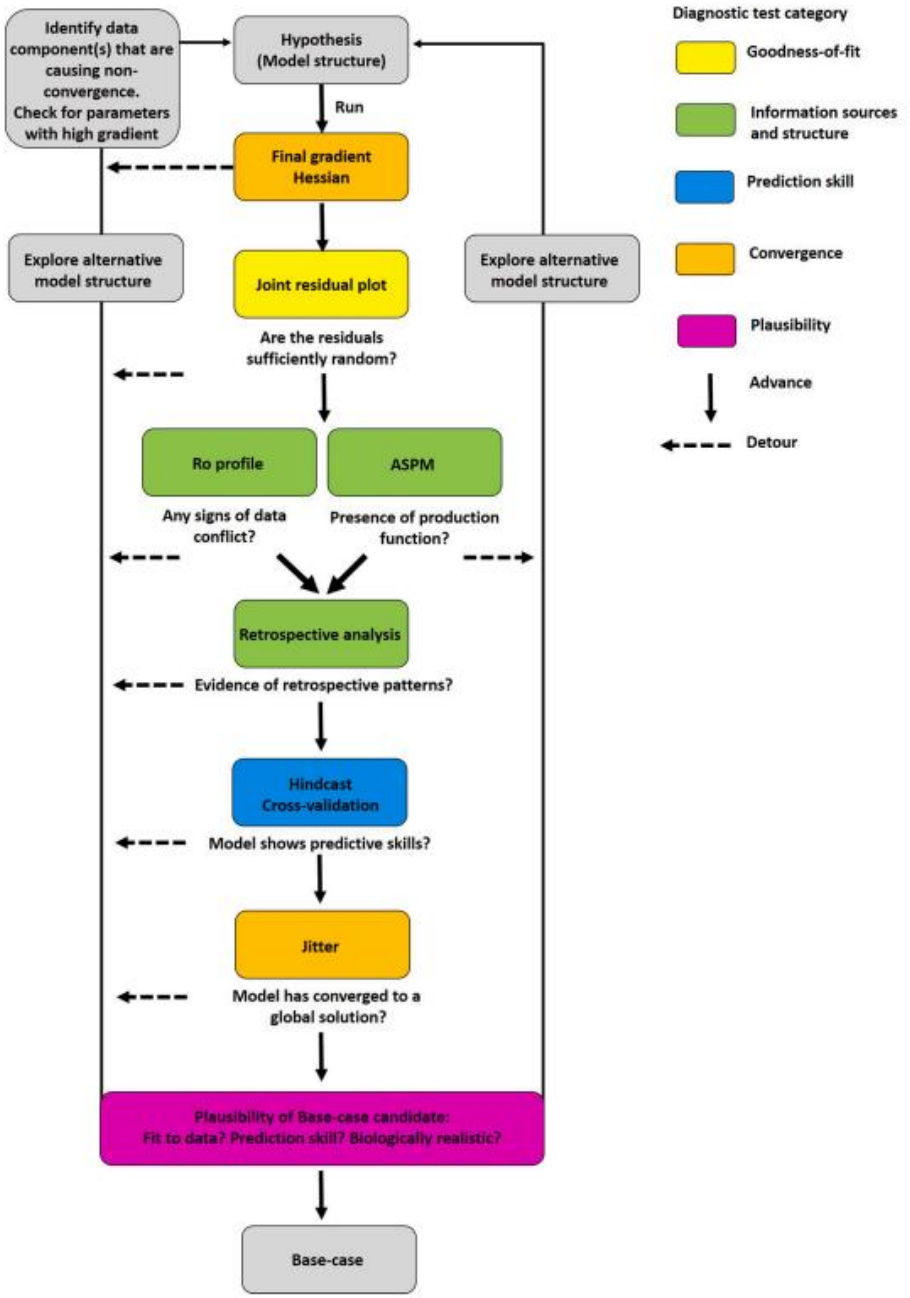


Fig. 1. Conceptual process flow chart illustrating a series of interconnected diagnostic tests recommended when developing a base model (or an ensemble of candidate models). The arrows represent broad guidance regarding the flow along the axis of diagnostic types from top to bottom. If diagnostic tests fail, a 'detour' path highlights the need for model exploration before advancing.

Model Convergence

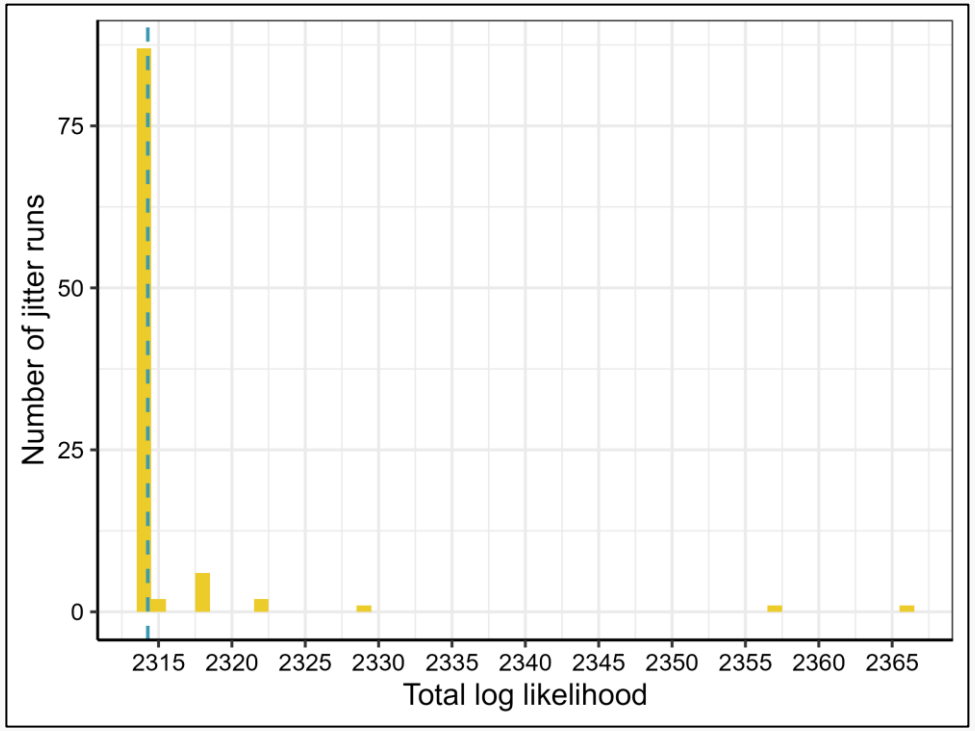
- No estimated parameters on the bounds
- Final gradient <0.0001
- Positive definite Hessian

Jitter Analysis

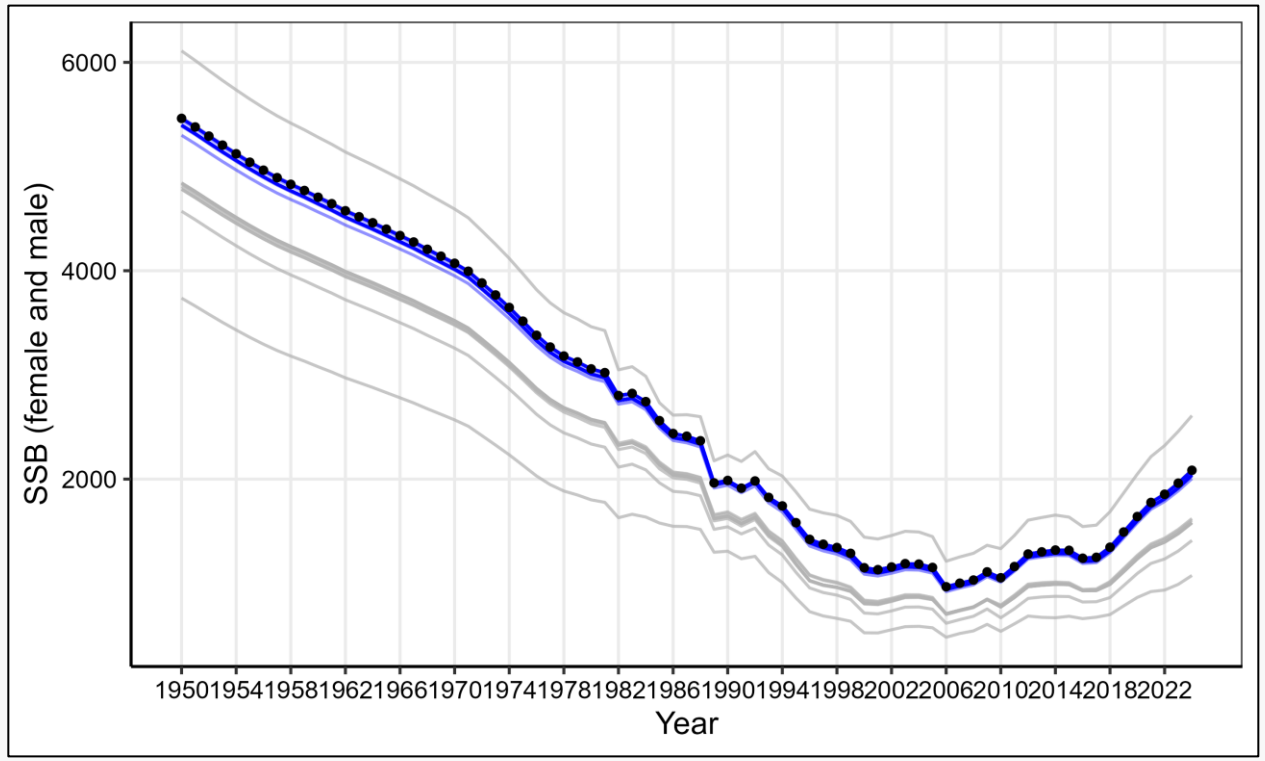
- 100 jittered runs
  - Initial values jittered by 20%
  - 70 runs (70%) had a low gradient (<0.0001) but no other run had a gradient >0.3174.
  - 89% within 2 LL units from min

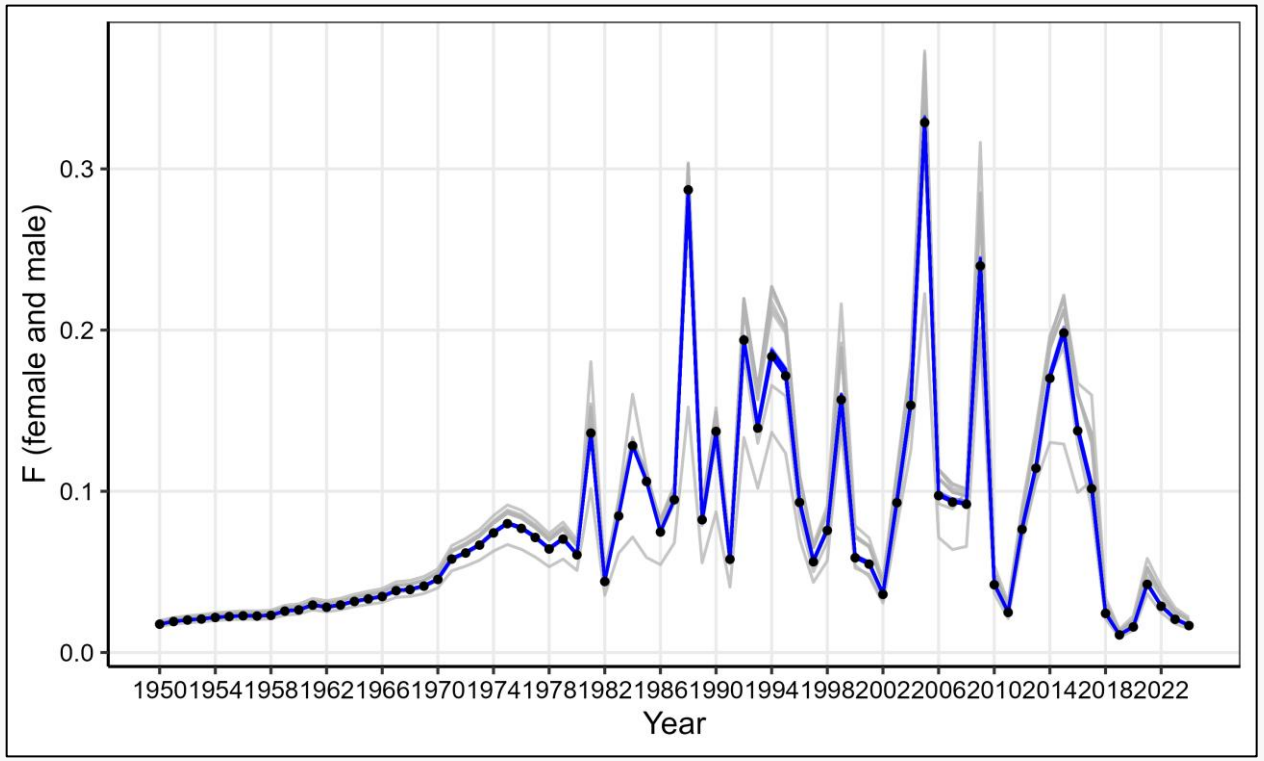
- No jittered runs contained a total likelihood lower than the KEYS base model.
- Results suggested that the KEYS base model had converged on a global solution.

Figure 3.45



Model Convergence





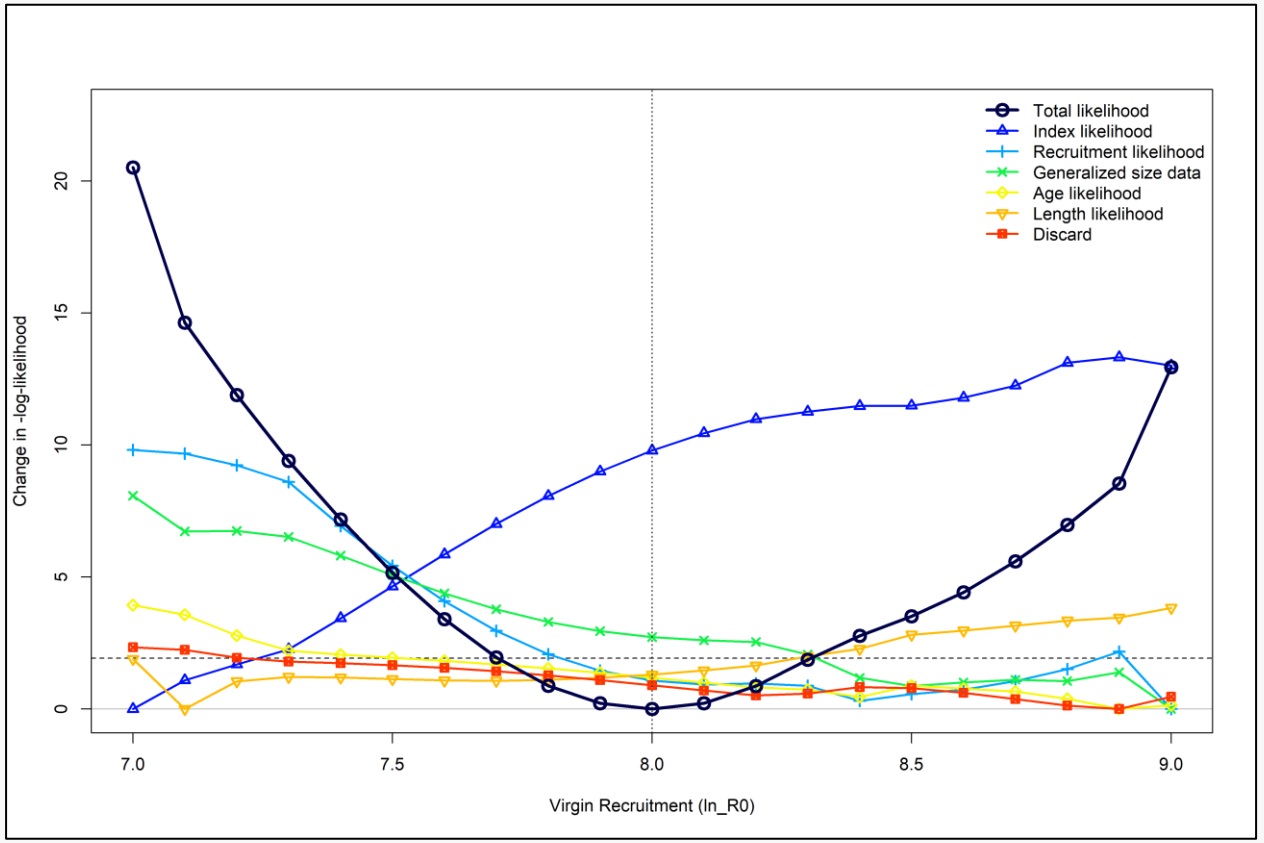
Blue highlight are runs within 2 LL unit of jitter minimum
Black dots are KEYS base model

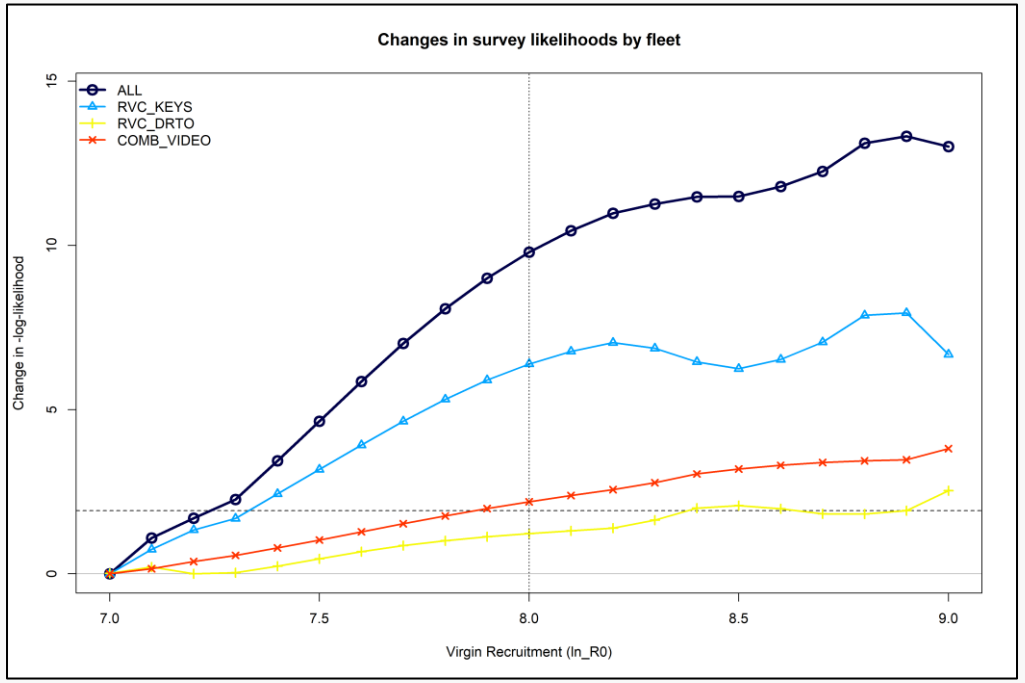
Model Consistency

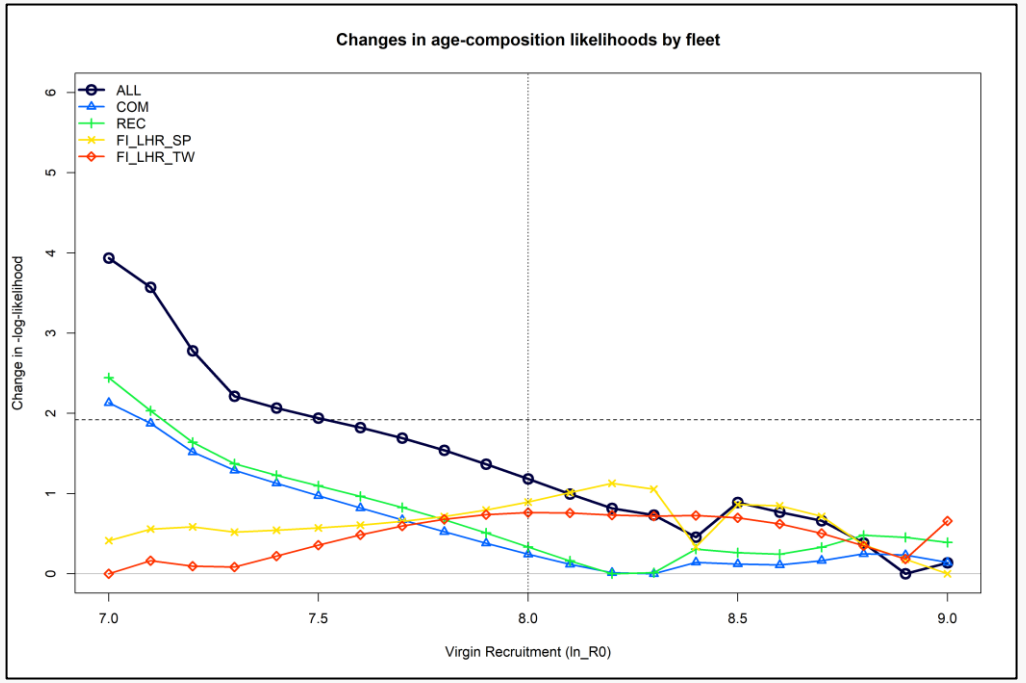
Profiling of R_0

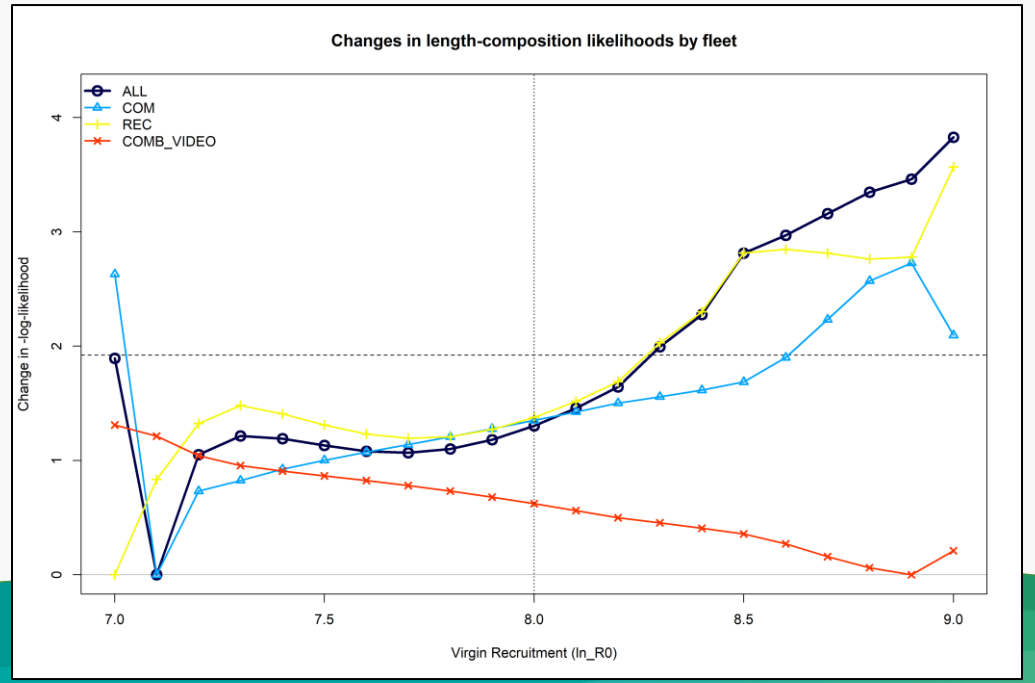
- Identify how sources of information influence various model estimates
- R_0 ≈ global scaling parameter
- Largely influenced by recruitment (light blue) and RVC size data (green) components
  - Conflicted with the index (dark blue) data component
- Minimum agrees with KEYS base model ($ln(R_0)$ = 8.0)
  - $ln(R_0)$ ~7.8 – 8.2 similar fit to data

Figure 3.50




Changes in survey likelihoods by fleet
ALL
RVC_KEYS
RVC_DRTO
COMB_VIDEO
Change in -log-likelihood
Virgin Recruitment (ln_R0)


Changes in age-composition likelihoods by fleet
ALL
COM
REC
FI_LHR_SP
FI_LHR_TW
Change in -log-likelihood
Virgin Recruitment (ln_R0)


Changes in length-composition likelihoods by fleet
ALL
COM
REC
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Change in -log-likelihood
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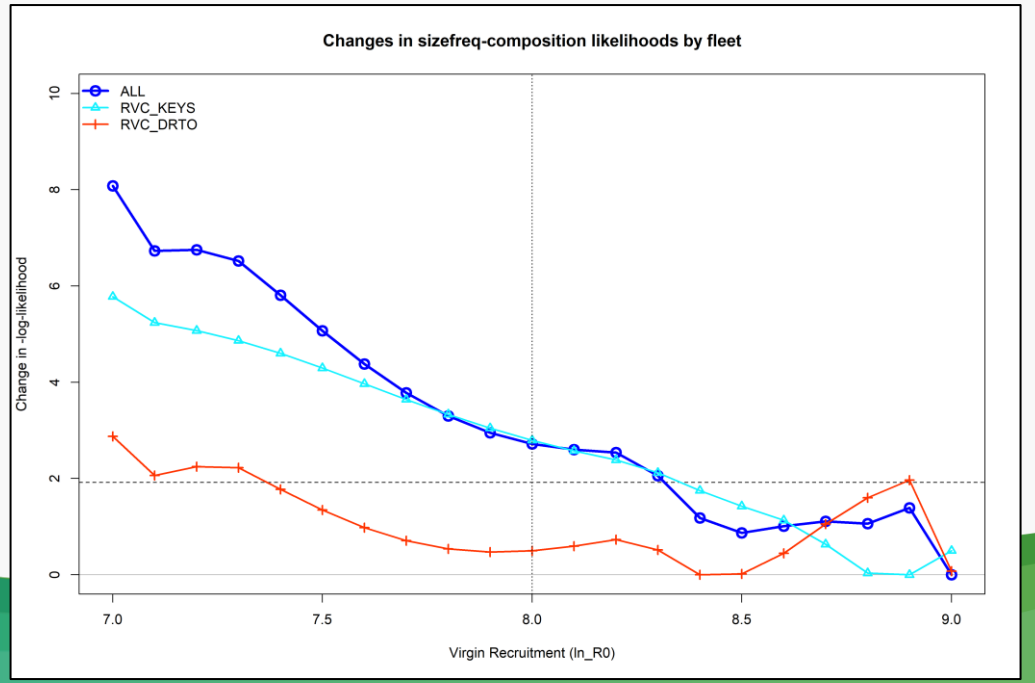
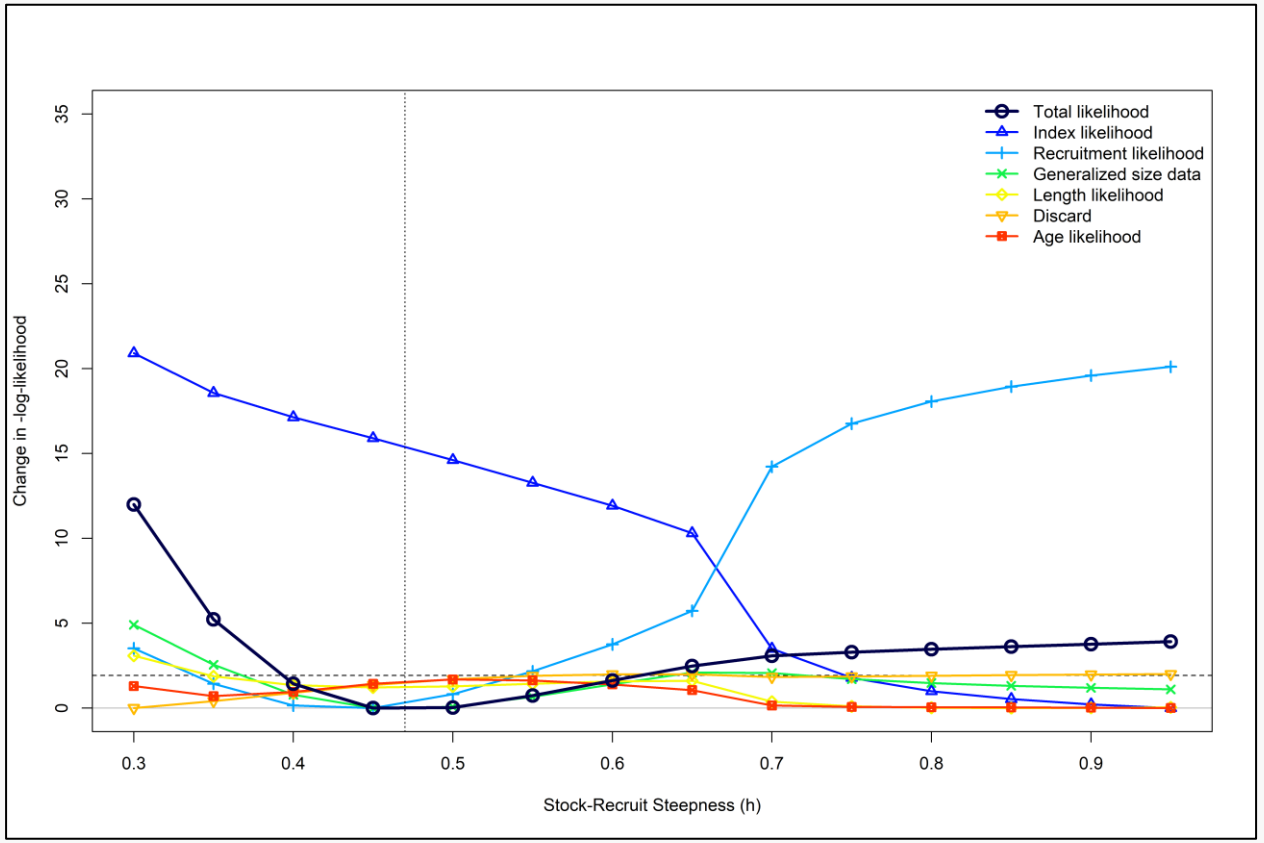

Changes in sizefreq-composition likelihoods by fleet
ALL
RVC_KEYS
RVC_DRTO
Change in -log-likelihood
Virgin Recruitment (ln_R0)

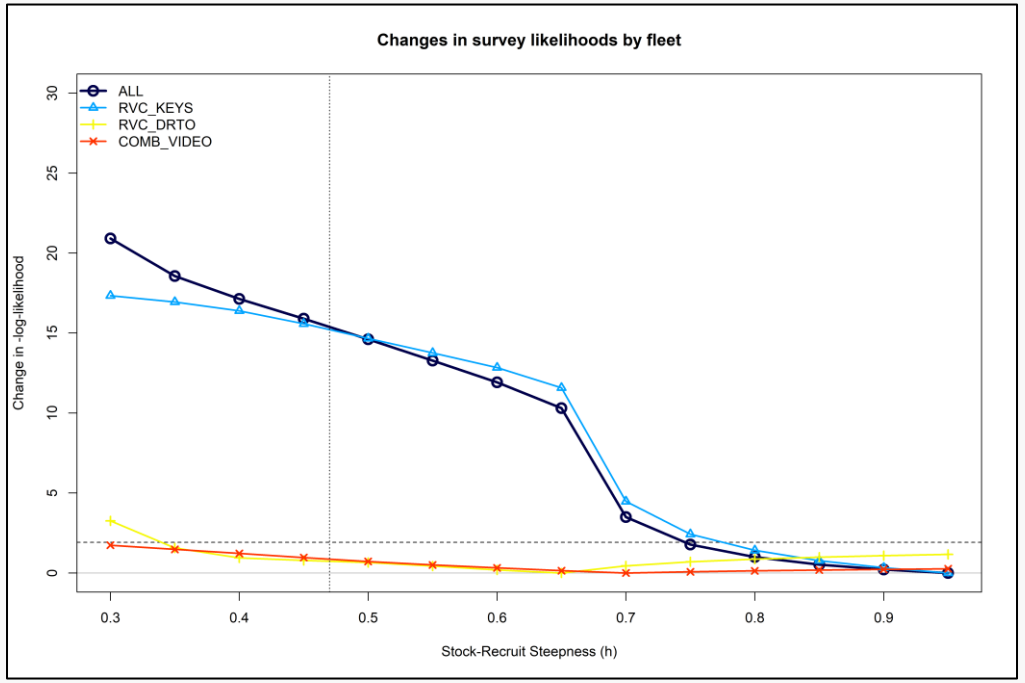
Model Consistency

Profiling of *steepness (h)*

- *steepness* largely influenced by the recruitment (light blue) component
  - Conflict with index (dark blue) data component
- Minimum agrees with base model (*steepness* = 0.47)
- Likelihood surface indicate value between 0.4 – 0.6
  - Recruitment component suggests between 0.35 – 0.5

Figure 3.51

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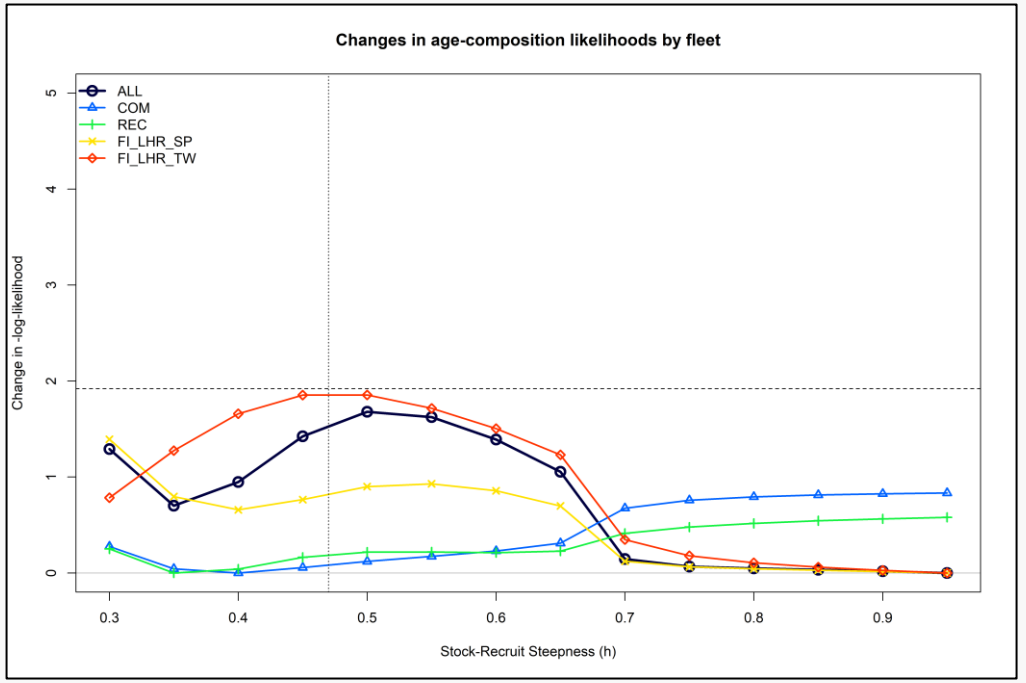
ALL
RVC_KEYS
RVC_DRTO
COMB_VIDEO
Change in -log-likelihood
Stock-Recruit Steepness (h)


Changes in age-composition likelihoods by fleet
ALL
COM
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Change in -log-likelihood
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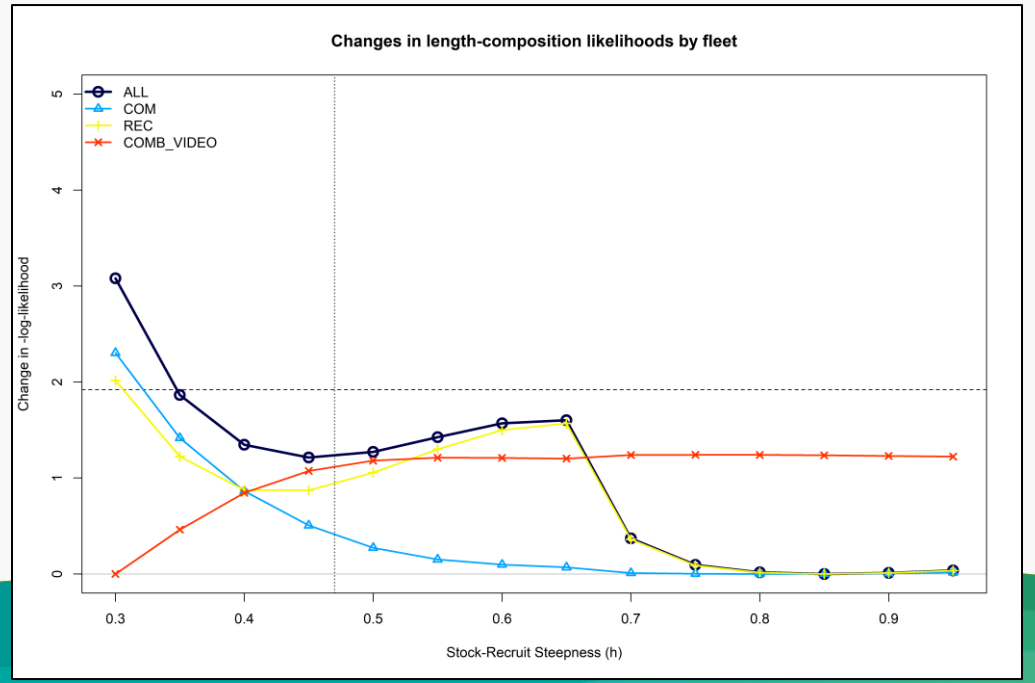
Changes in length-composition likelihoods by fleet
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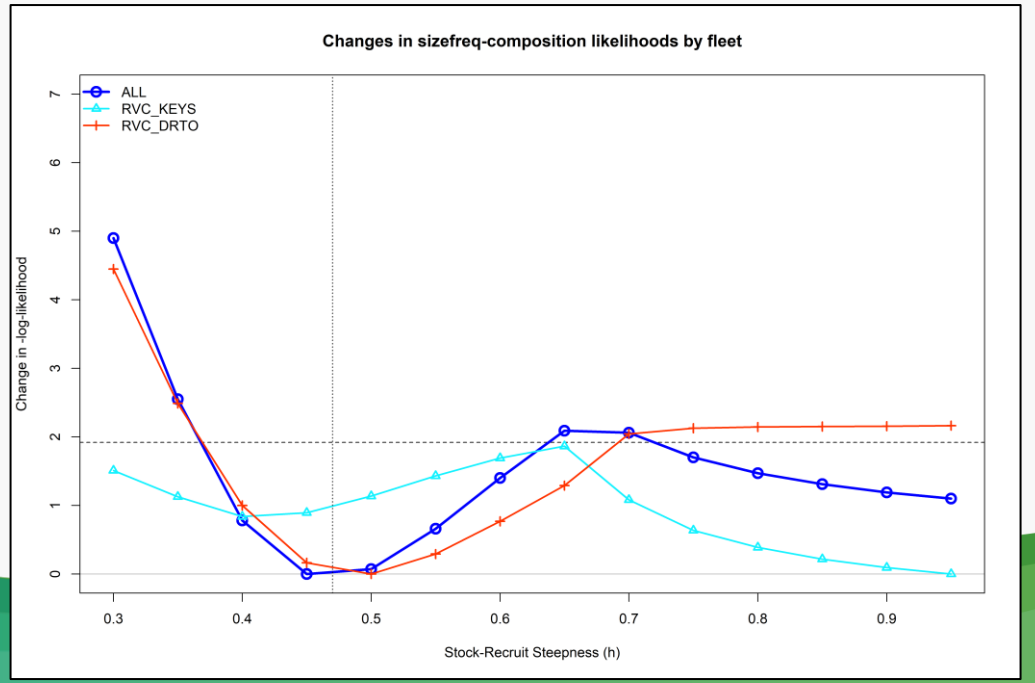
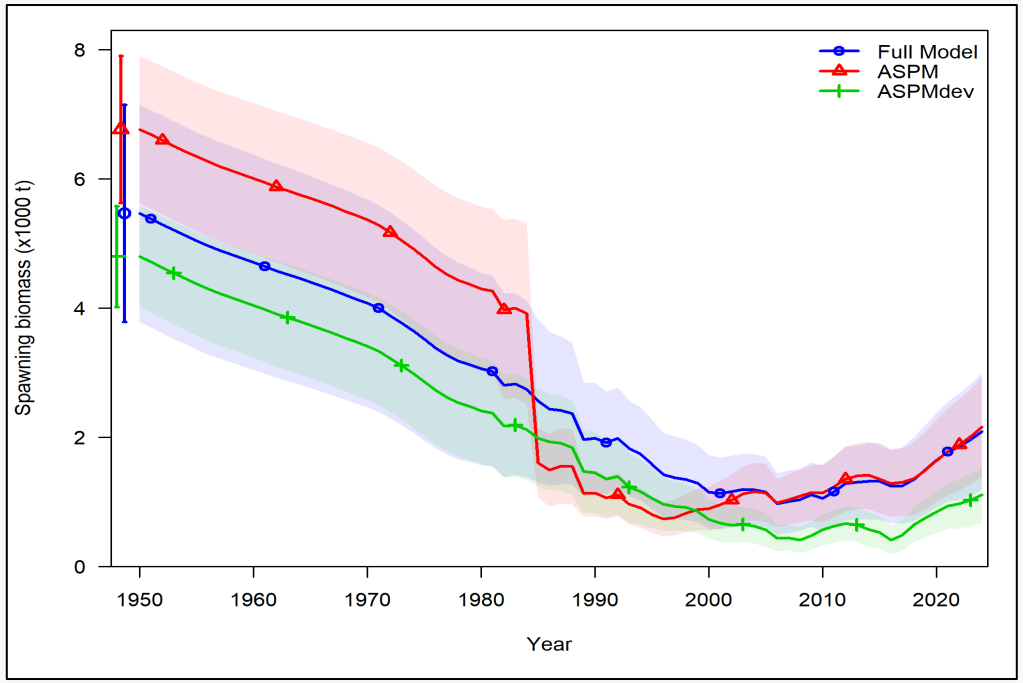
Stock-Recruit Steepness (h)

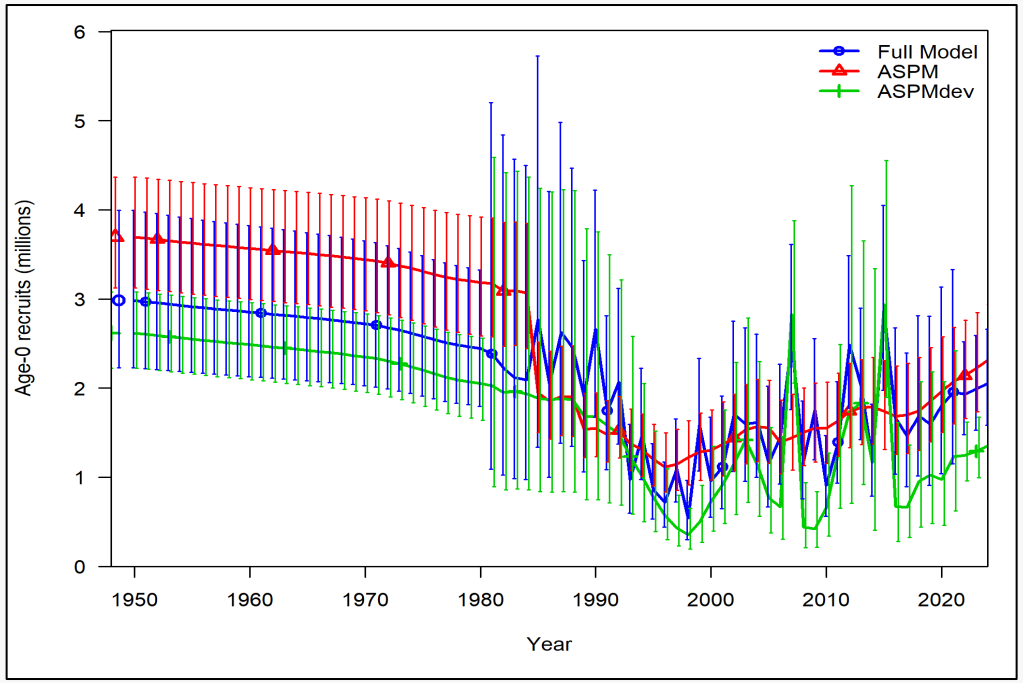

Changes in sizefreq-composition likelihoods by fleet
ALL
RVC_KEYS
RVC_DRTO
Change in -log-likelihood
Stock-Recruit Steepness (h)

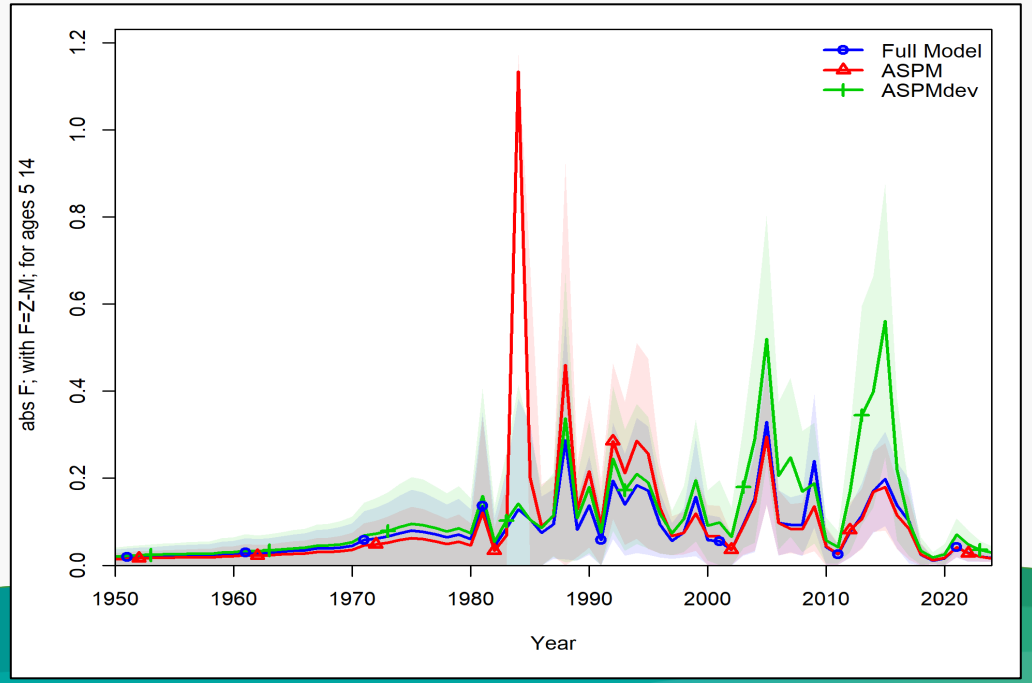
Model Consistency

Age Structured Production Models (ASPM)

- Results of the models indicated the production function was largely able to drive stock dynamics.
  - Showed a decrease of SSB in response to early fishing pressures and lower index values.
  - Responded to decreased catch and increasing indices post-2017.
  - Largely estimated similar scale and trend
- ASPM needed to use observation error in catch
  - e.g., artificially high F in mid-1980s to bring down population scale
- ASPM_dev used recruitment deviations (process error) to further improve fit to indices


Full Model
ASPM
ASPMdev
Spawning biomass (x1000 t)
Year


Full Model
ASPM
ASPMdev
Age-0 recruits (millions)
Year


Full Model
ASPM
ASPMdev
abs F; with F=Z-M; for ages 5 14
Year

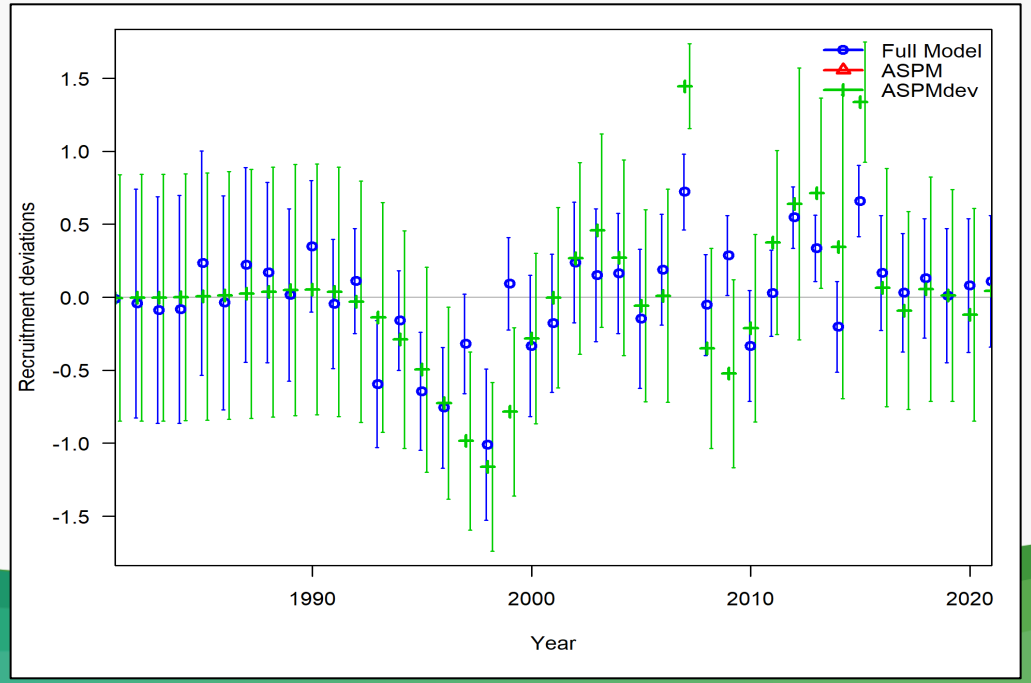
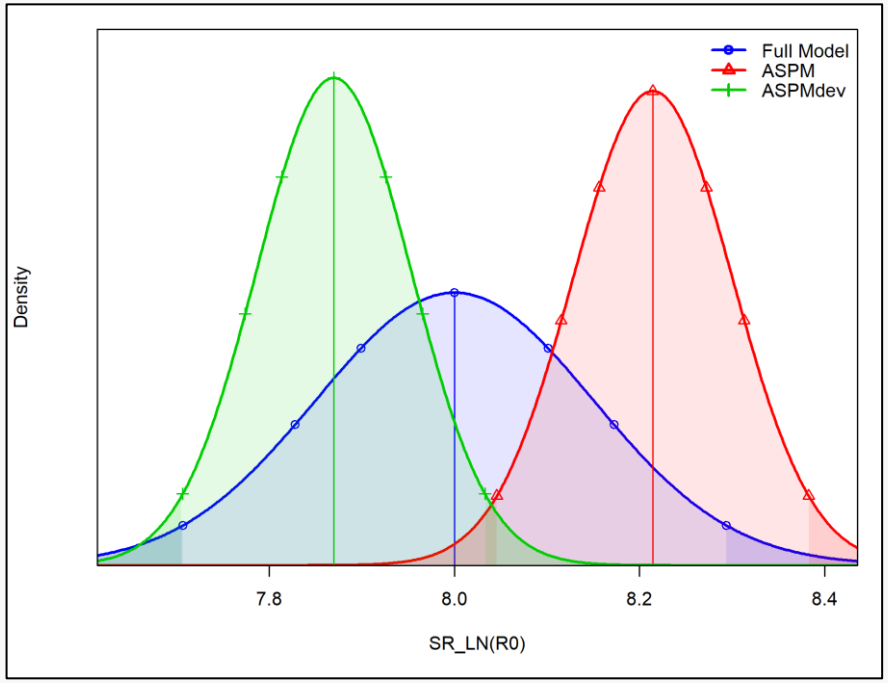
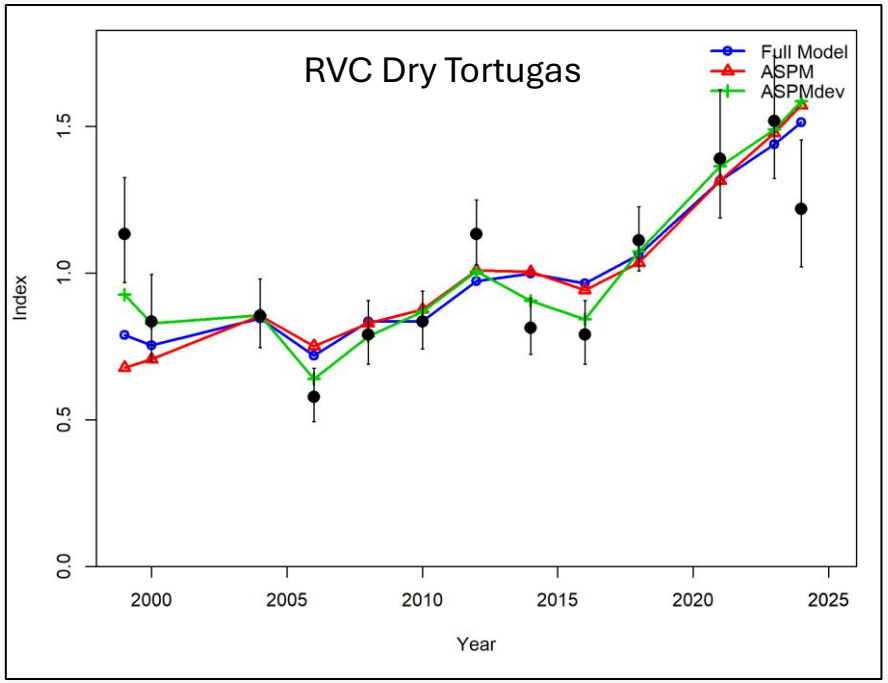

Full Model
ASPM
ASPMdev
Recruitment deviations
Year

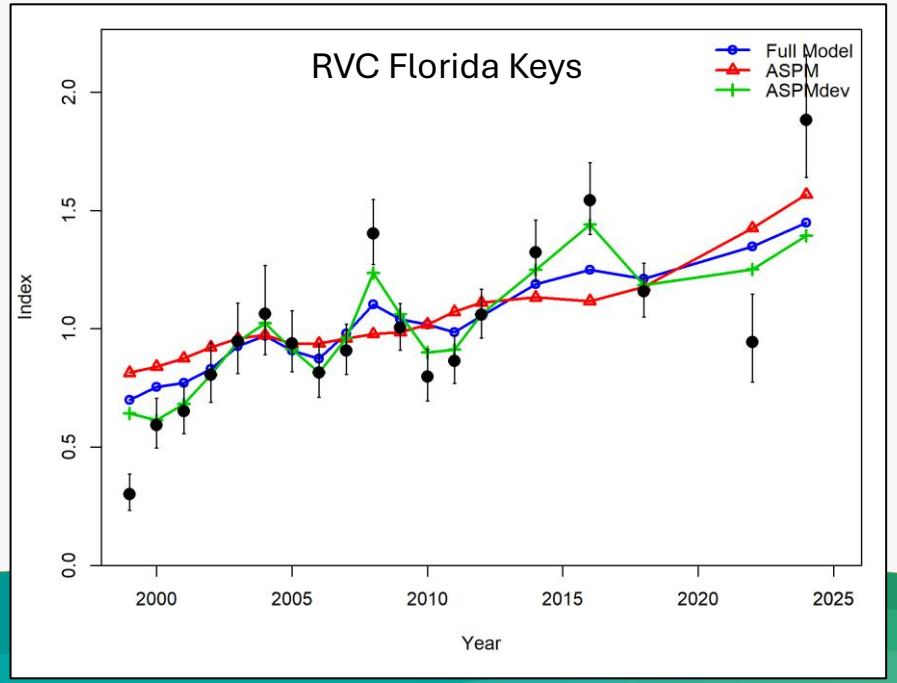
Figure 3.52

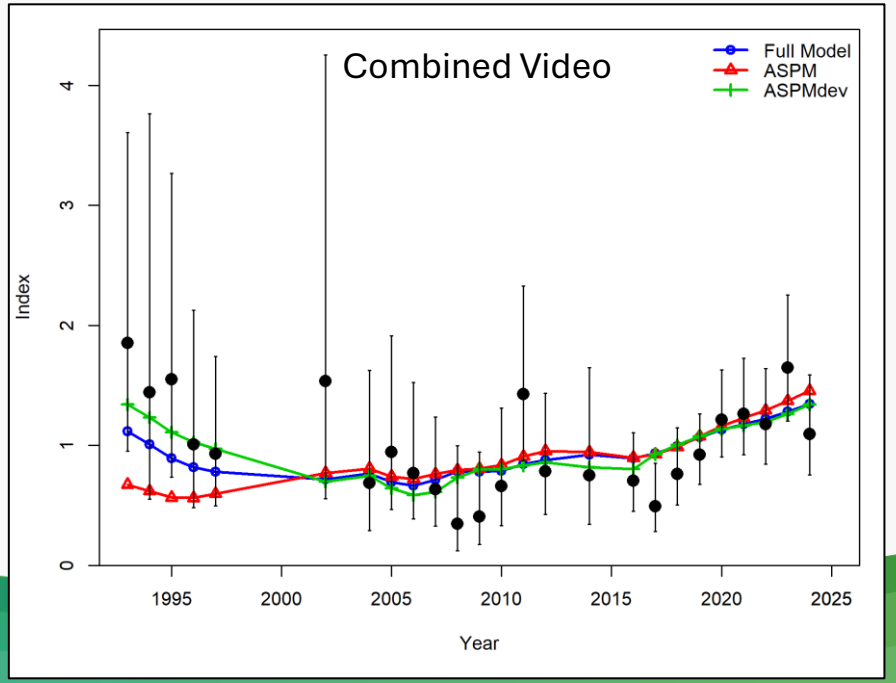
Figure 3.53

Some Agreement with $ln(R_0)$ profile









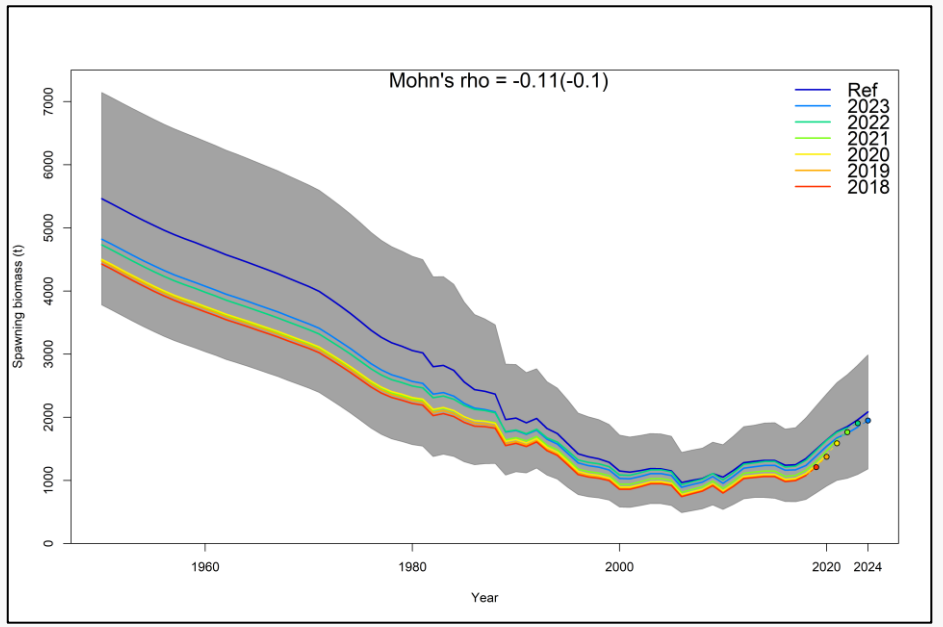
Model Consistency and Predictive Skill

Retrospective Analysis

- Helps evaluate the effect of the final years on model results where patterns can indicate model misspecification or temporal dynamics
- Evaluated visually and quantitatively
  - Mohn's Rho
  - Hurtado –Ferro et al (2015) "Rule of thumb"
    - - 0.15 to 0.20 for longer-lived species
- Six-year peel (2018 – 2023)
  - Terminal time block
  - Values within Rho bounds and model uncertainty
    - Pattern detected when main recruitment deviations extended to 2024

Retrospective Forecasting

- Model-based hindcasts to six-year peels
- Evaluated visually and quantitatively
  - Forecast bias corresponding to Mohn's Rho



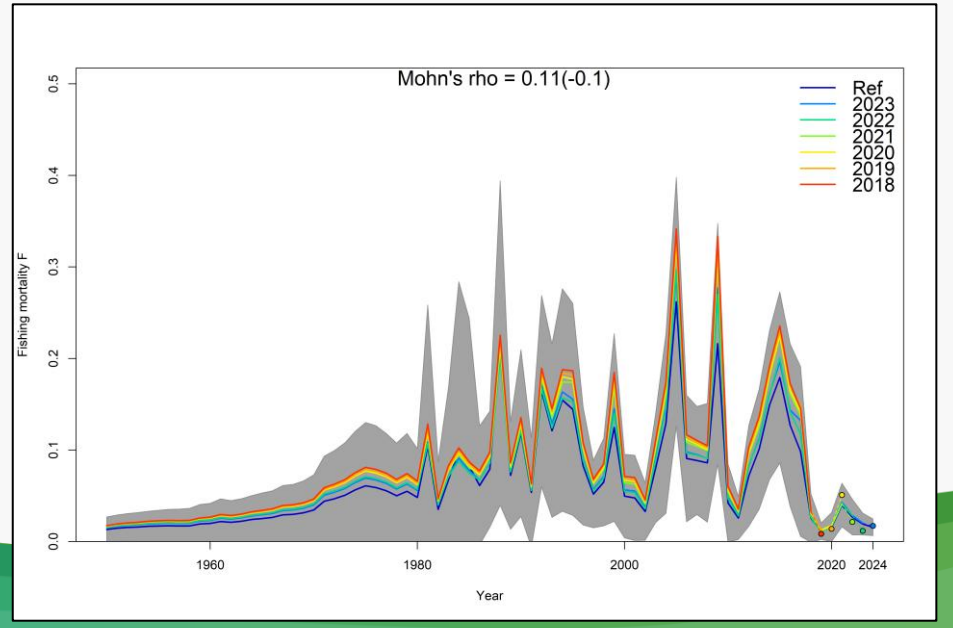


Figure 3.54

Predictive Skill

Table 3.15

Model Component	Data Source	MASE	Model MAE	Naïve MAE	N
Index of Abundance	RVC Florida Keys	0.693	0.311	0.448	2
	RVC Dry Tortugas	0.672	0.119	0.177	3
	Combined Video	0.628	0.139	0.221	6
	Combined	0.657	0.165	0.250	11
Conditional Age-at-Length	Recreational	0.305	0.091	0.298	3
	FI Spear	0.142	0.019	0.134	1
	FI Trawl	0.040	0.038	0.944	1
	Combined	0.167	0.066	0.395	5
Size Composition	RVC Florida Keys	1.984	0.120	0.060	2
	RVC Dry Tortugas	0.597	0.038	0.064	3
	Combined	1.132	0.071	0.063	5

*** MASE (Mean Absolute Scaled Error) = Average of mean absolute error of prediction residuals (Model MAE)/Naïve Predictions (Naïve MAE)

Sensitivity Runs

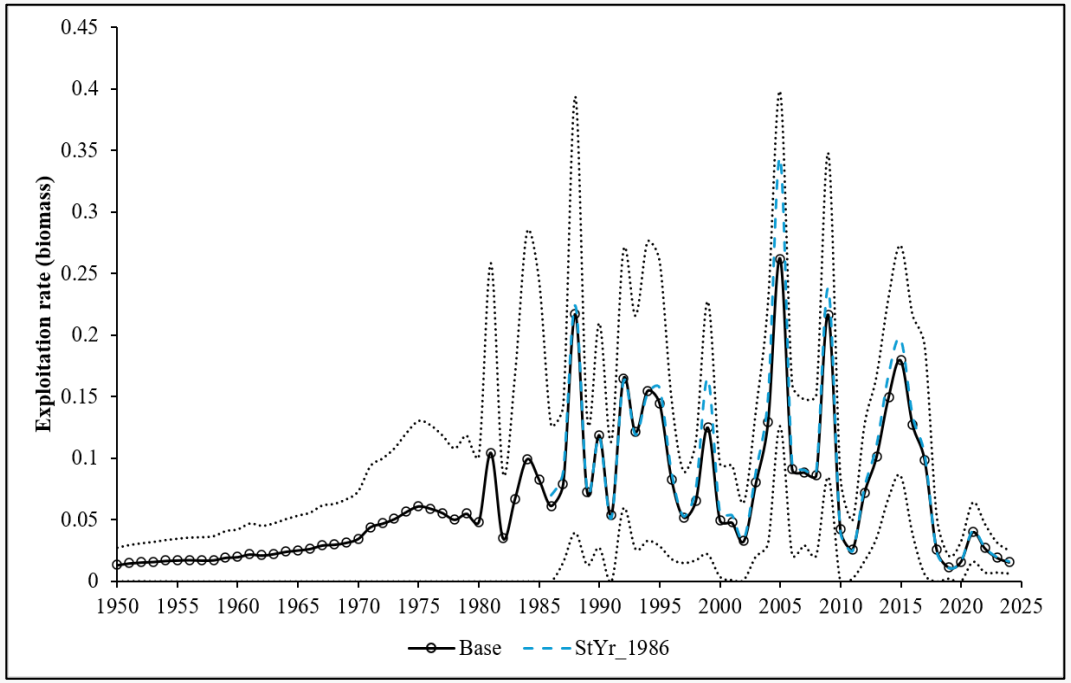
Start Year 1986

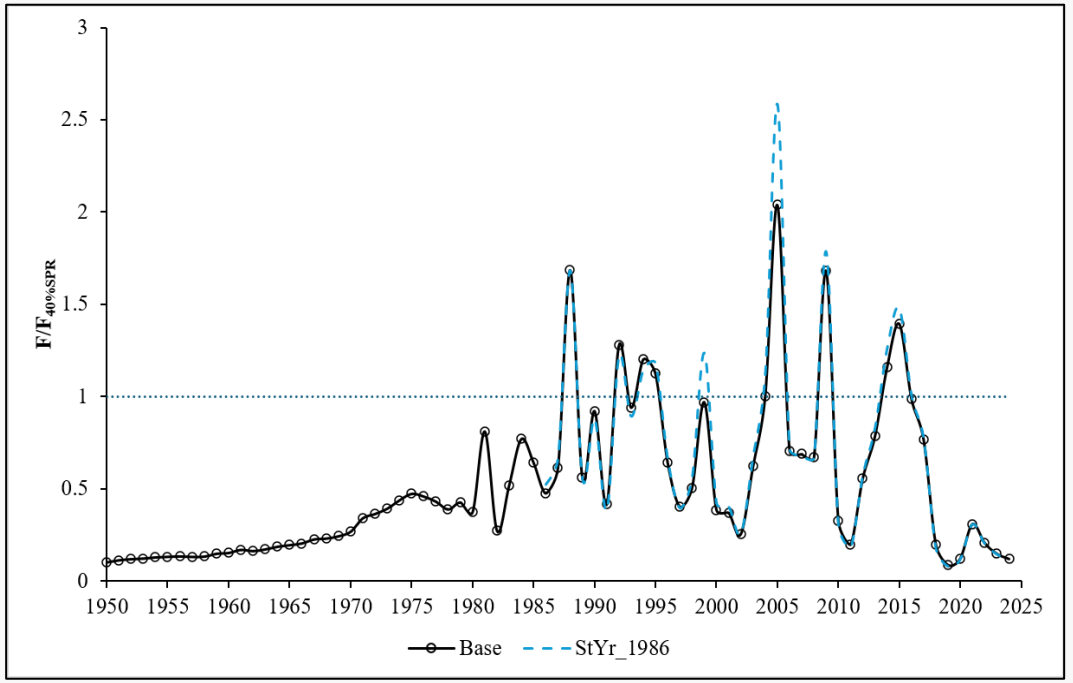
- No historical commercial or reconstructed recreational landings
- *steepness* = 0.99
  - Not enough information in data to estimate a differing value
  - Parameter profile suggests improved fit to data with low value

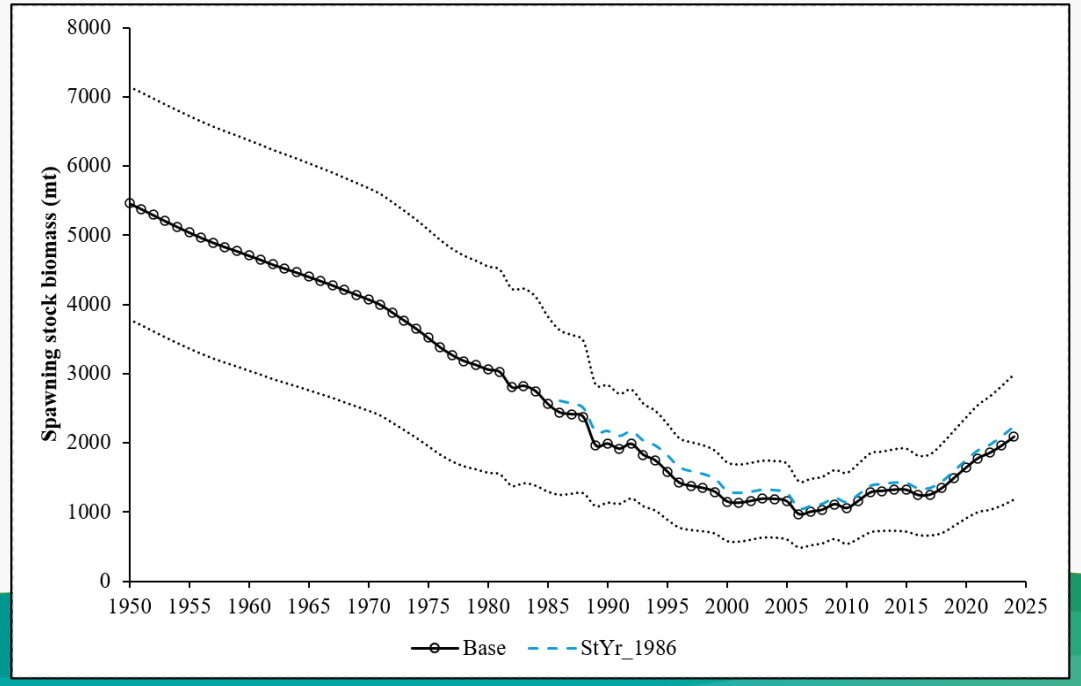
- Estimates of SSB, exploitation, and recruitment consistent with KEYS base model (<10% difference on average)
- Differ in model's stock productivity and subsequent SPR-based reference values for SSB
  - No stock-recruitment relationship means greater recruitment at lower stock sizes and lower recruitment at greater stock sizes

Figure 3.55a-d

Diagnostic | Uncertainty | SSDC | Bridge







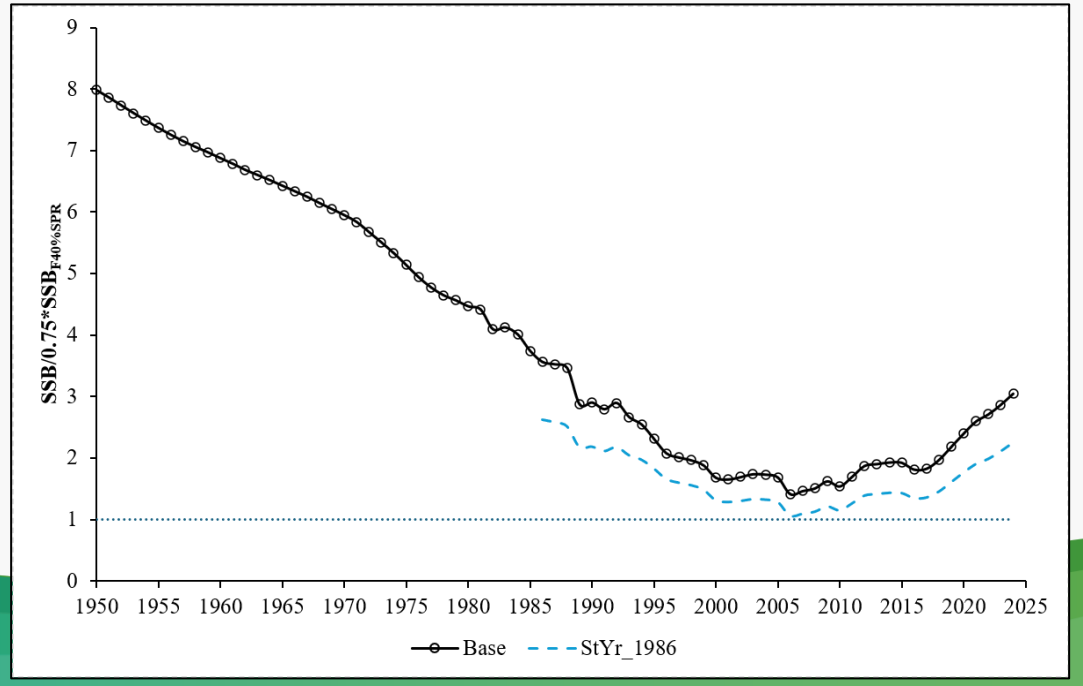
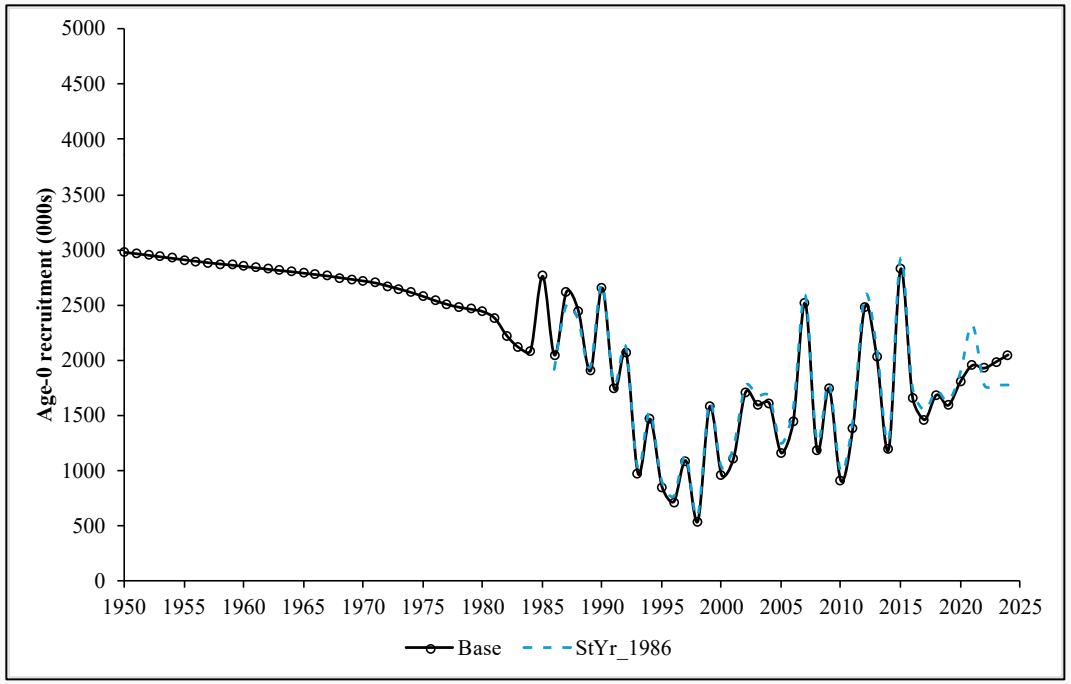
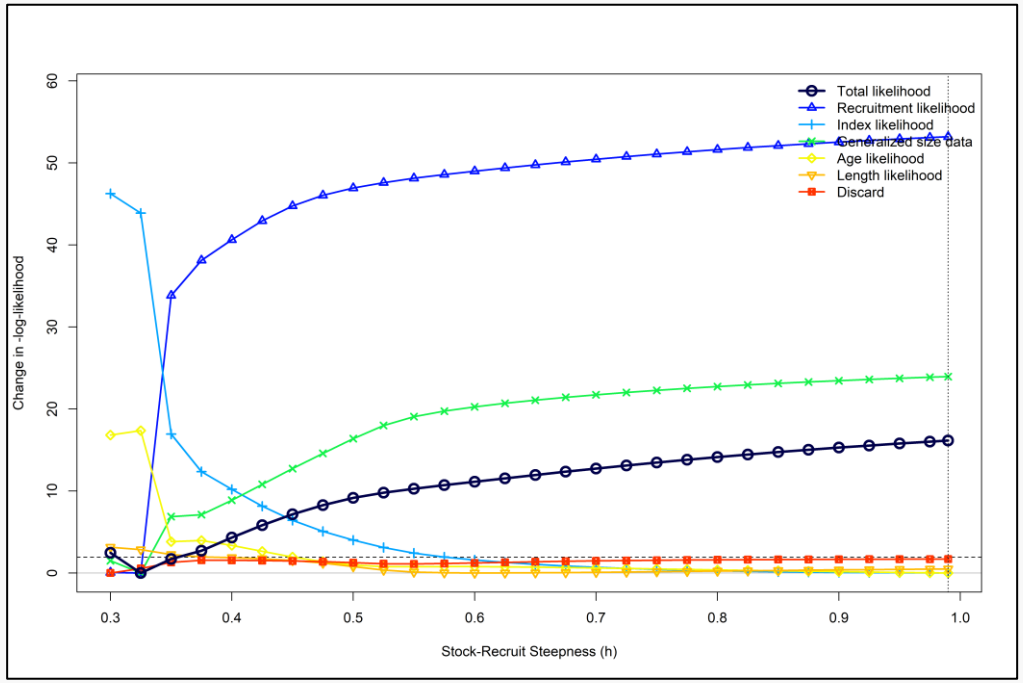
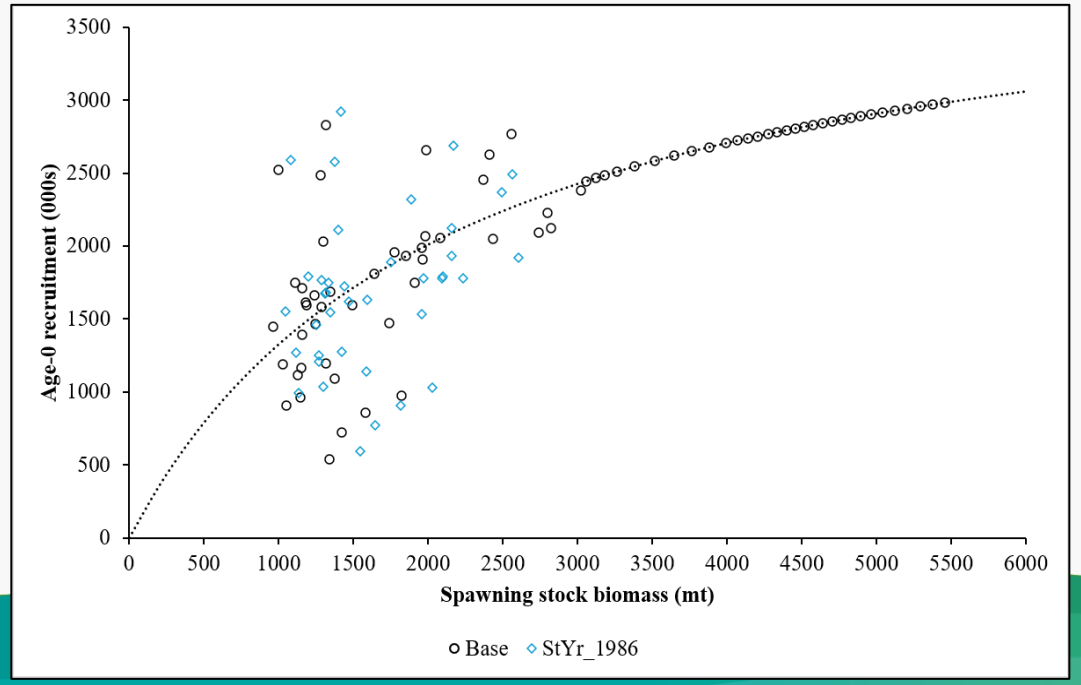


Figure 3.55e-g







Sensitivity Runs

Recreational Discard Mortality Rates

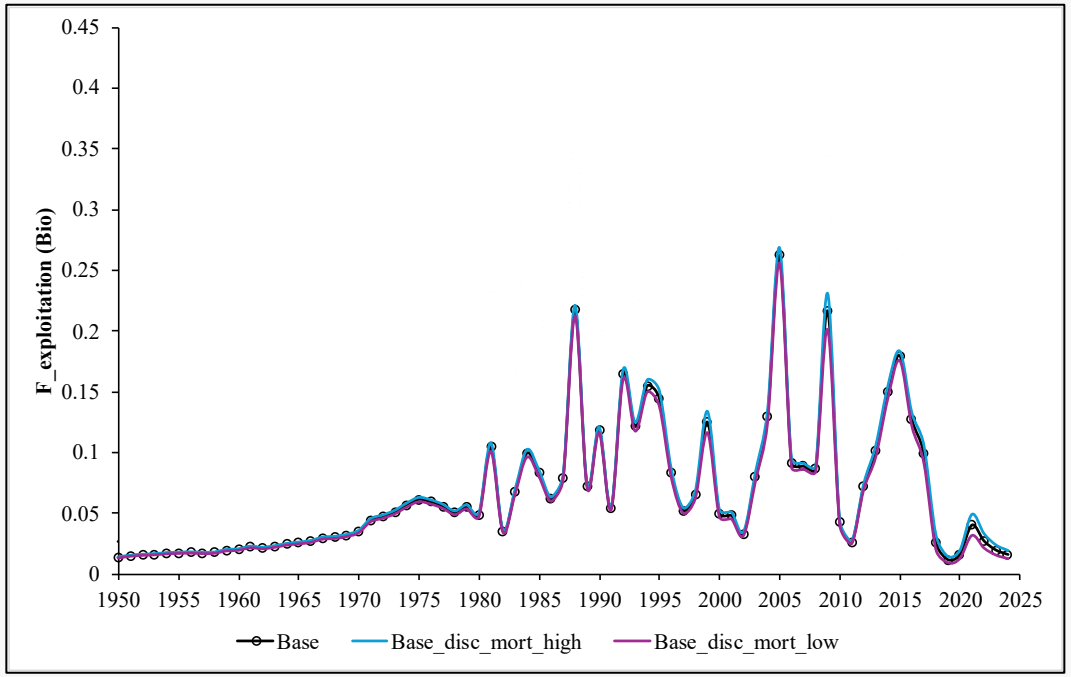
- Low = 23.8%
- High = 59%

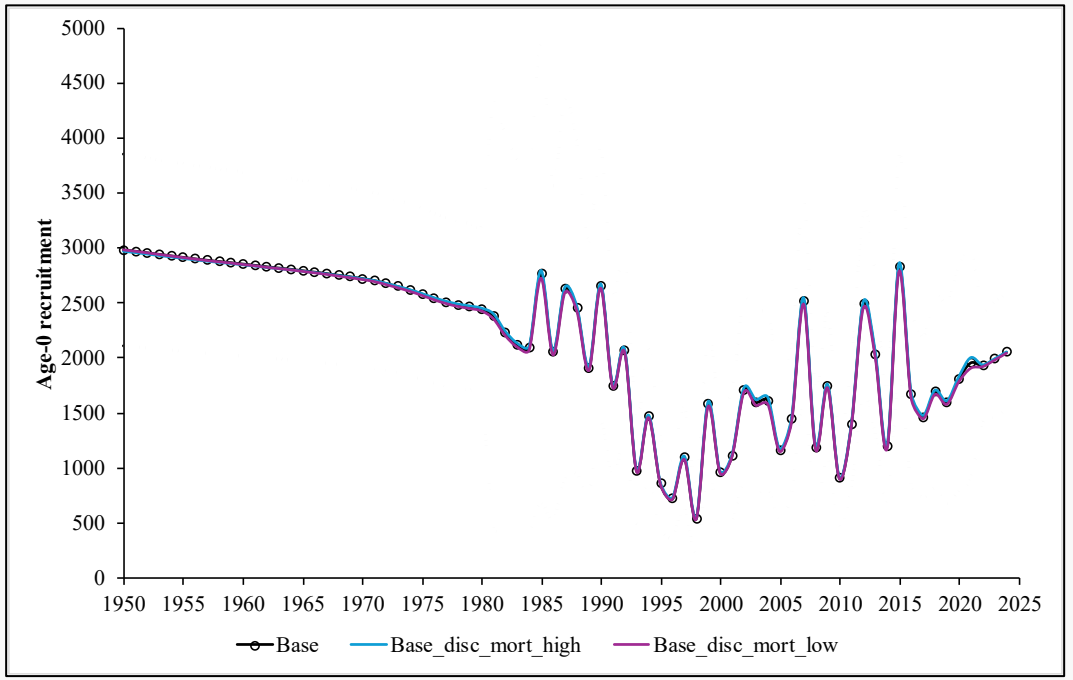
- Model rather insensitive to changes in recreational discard mortality.
- Higher rates corresponded to higher exploitation rates, and vice-versa.
  - on average a 5% difference
- Increases in exploitation corresponded to decreases in spawning stock biomass.
  - average 2% change
- Age-0 recruitment was nearly unchanged with <1% average difference.

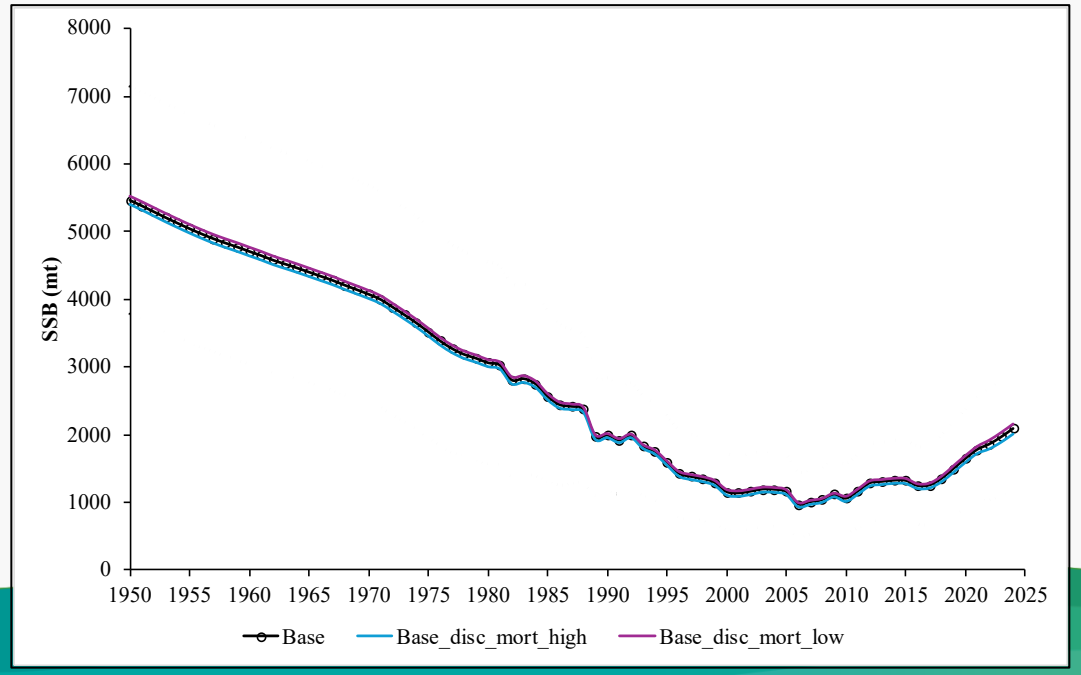
- Recreational discards comprised on average 30% of recreational total catch
  - Increased during 2018 – 2024 (avg. 80%) where population response mainly observed

Figure 3.56

Diagnostic | Uncertainty | SSDC | Bridge







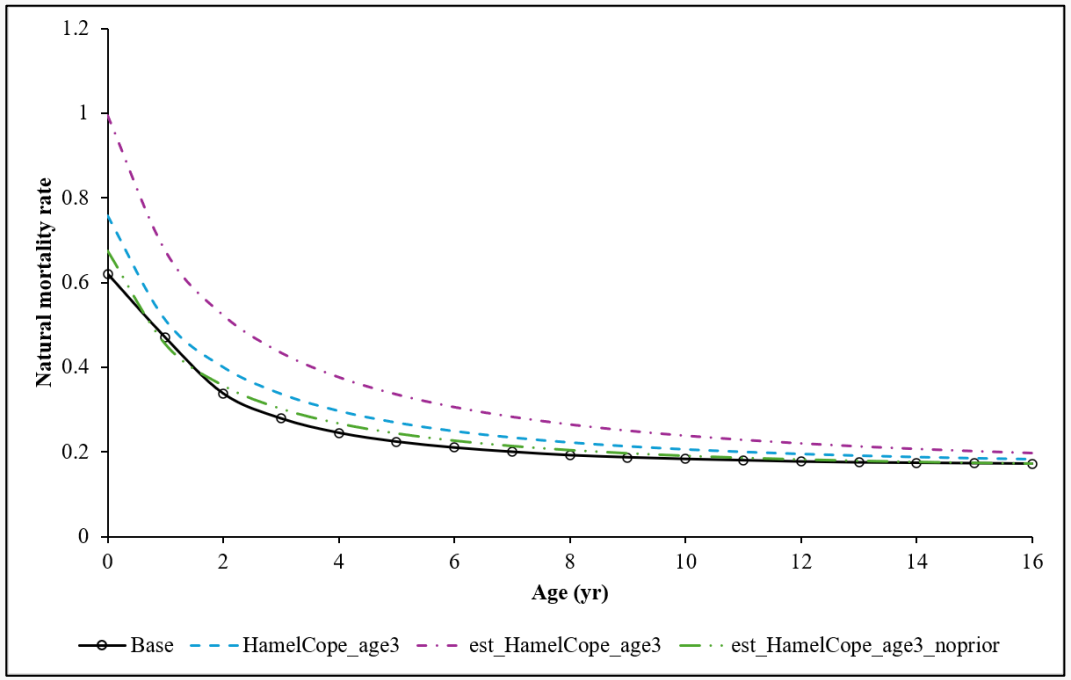
Sensitivity Runs

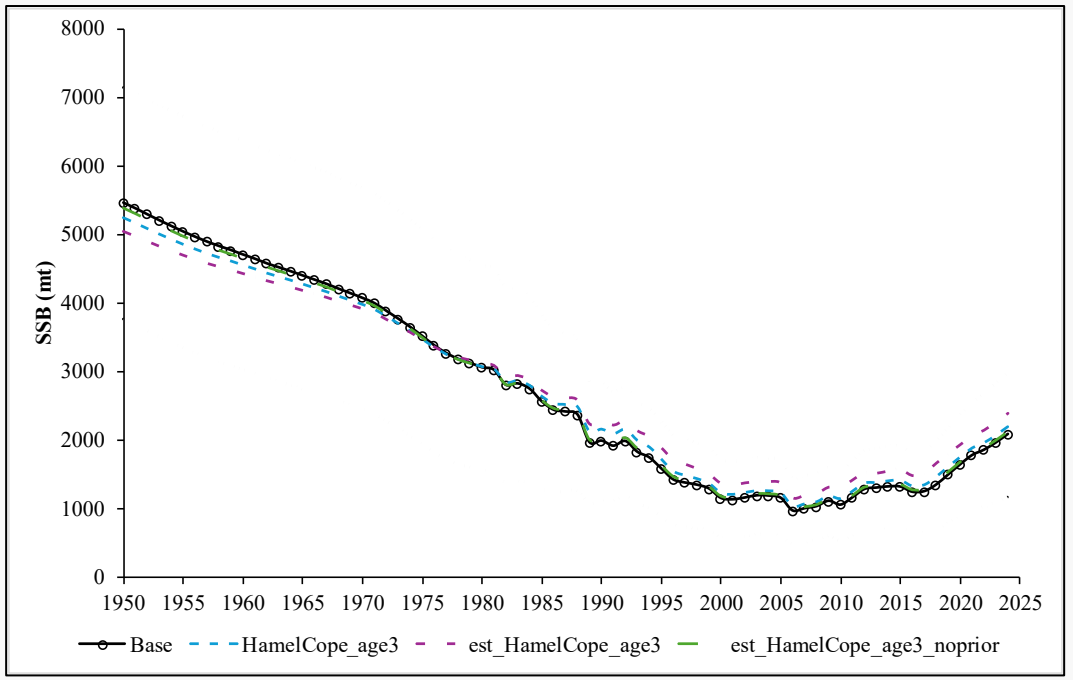
Natural Mortality

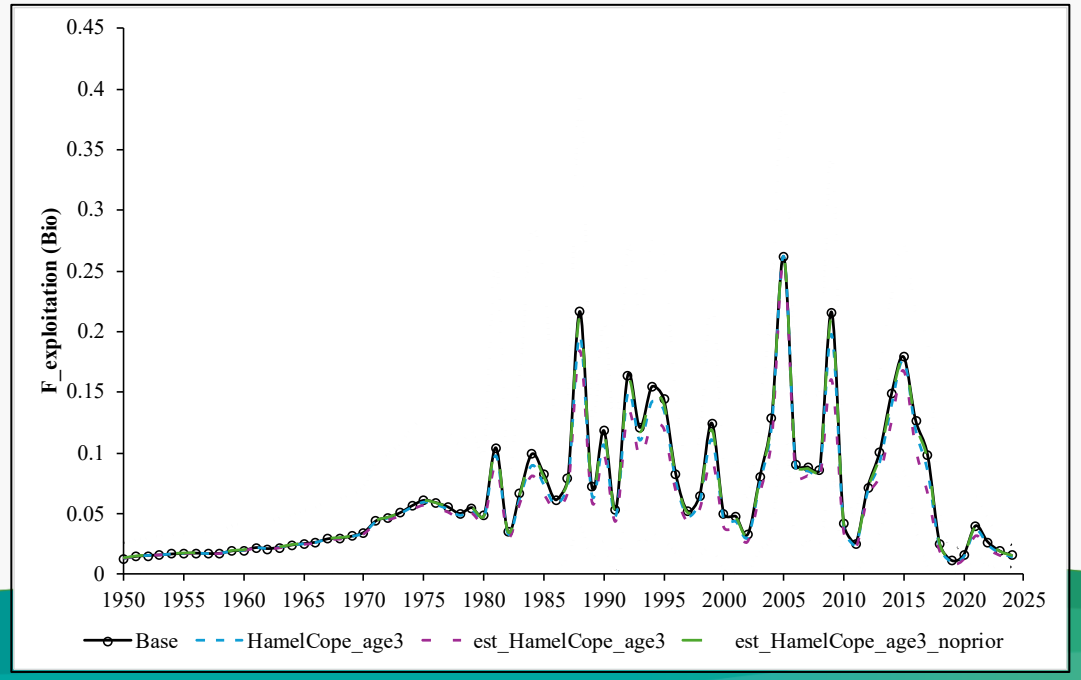
- 1) Longevity-based estimator (max. age 16) for reference age-3
  - $M = 0.338\ yr^{-1}$
    - "HamelCope_age3" scenario
- 2) Longevity-based estimator using a standard deviation prior (0.31, in log-space)
  - $M = 0.435\ yr^{-1}$ at reference age-3
    - "est_HamelCope_age3" scenario
- 3) Longevity-based estimator freely estimated within model
  - $M = 0.312\ yr^{-1}$ at reference age-3
    - "est_HamelCope_age3_noprior" scenario

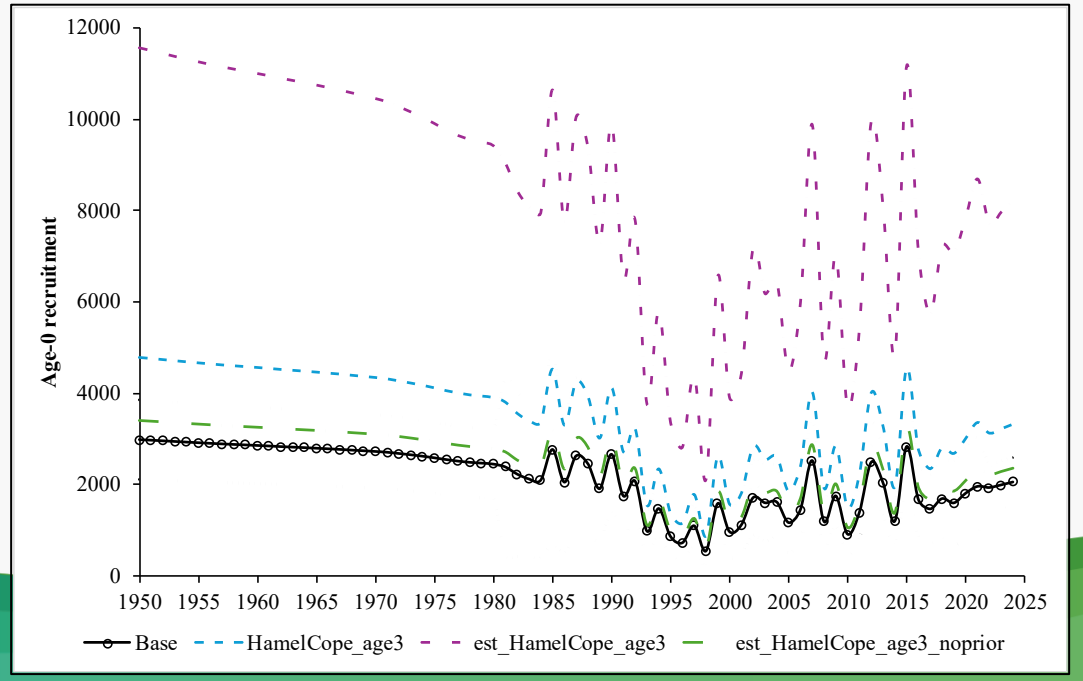
- Scalar responses where increased *M* led to increased age-0 recruitment
- 'HamelCope_age3' and 'est_HamelCope_age3_noprior' scenarios fit the data similarly to the KEYS base model (i.e., within 2 LL units)
  - Model outputs and estimates of life history and stock-recruitment parameters comparable.
- Use of standard deviation (log-space) prior resulted in worsened fits to the data
  - Estimates of life history and stock-recruitment parameters compensated for elevated mortality

Figure 3.57


Natural mortality rate
Age (yr)
Base
HamelCope_age3
est_HamelCope_age3
est_HamelCope_age3_noprior


SSB (mt)
Base
HamelCope_age3
est_HamelCope_age3
est_HamelCope_age3_noprior


F_exploitation (Bio)
Base
HamelCope_age3
est_HamelCope_age3
est_HamelCope_age3_noprior


Age-0 recruitment
Base
HamelCope_age3
est_HamelCope_age3
est_HamelCope_age3_noprior

SEDAR 94: Florida Hogfish

KEYS Base Model Uncertainty

Model Uncertainty

Markov chain Monte-Carlo (MCMC)

- Generate posterior distributions of model parameters and derived quantities
  - R_0, SSB_0, *steepness*, SSB_{2024}, F_{2024},
  - F_{MSY}, SSB_{MSY}, $F_{40\%SPR}$, $SSB_{F40\%SPR}$, Retained yield at F_{MSY}
- Convergence
  - Visual inspection of trace plots
  - Geweke's diagnostic for single chains
  - Gelman and Rubin's (1992) potential scale reduction factor (PSRF) for combined chain
- Six chains
  - 4,000 iterations saved from the 2,000,000 performed
  - Burn-in set at 800 with thin rate of 8
  - 400 iterations remained for each chain
    - Combined total = 2,400 iterations

Model Uncertainty

KEYS MCMC "proxy" model

- Developed due to structural constraints within KEYS base model
  - 1) Sum-to-zero constraint on recruitment deviations removed
    - Main recruitment deviations extended to 2024
  - 2) F-as-parameter allows simulants too much space to iterate over, leading to poor mixing and slow convergence

- Method for reconfiguring F:
  - F_{par} for Recreational fleet changed to F_{hybrid}
    - Fits landings exactly → used expected values from KEYS base model as landings input
  - F_{hybrid} already configured for Commercial fleet (no change)
  - Result: expected Recreational and Commercial landings same between models
    - Annual F values between models also the same

- Differences between KEYS base model and "proxy" model attributed to differences caused by configuration change to recruitment deviations

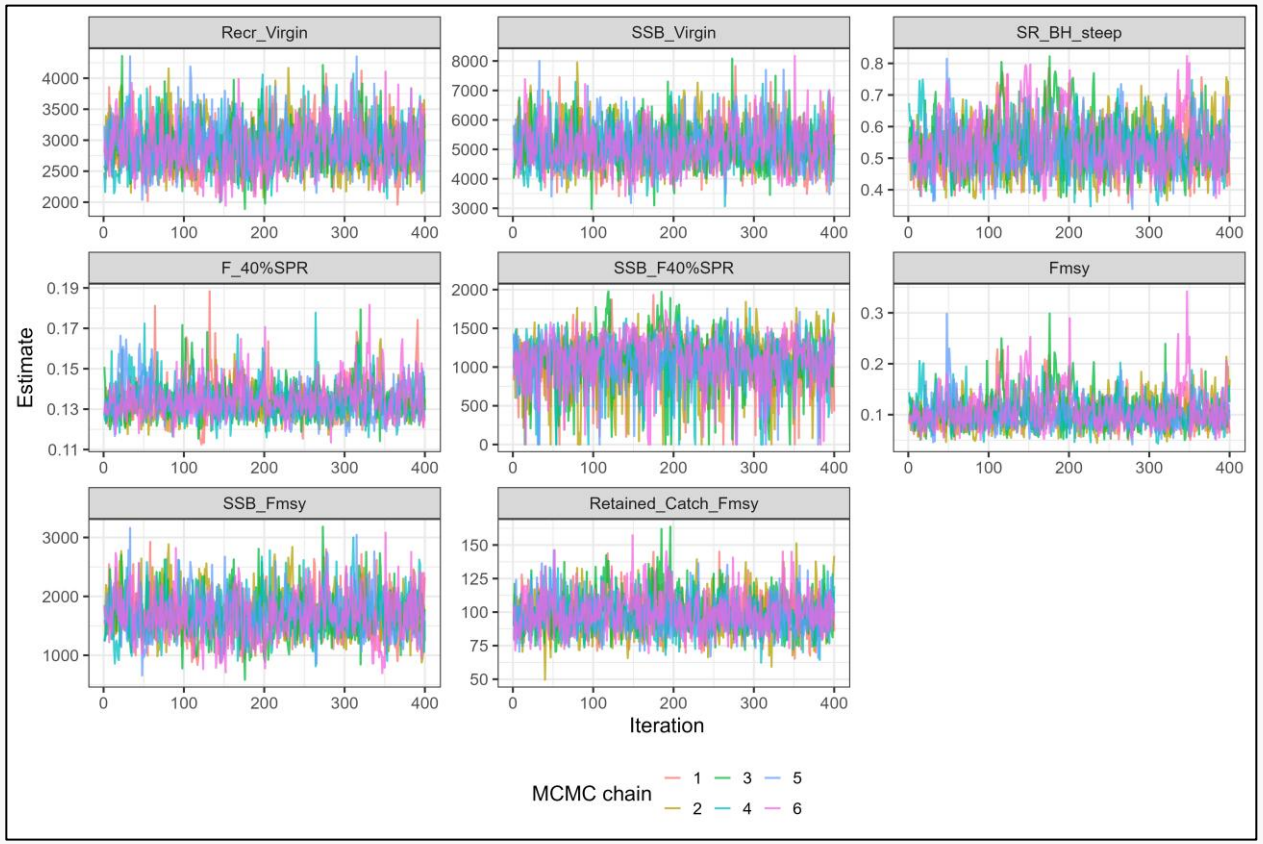
Model Uncertainty

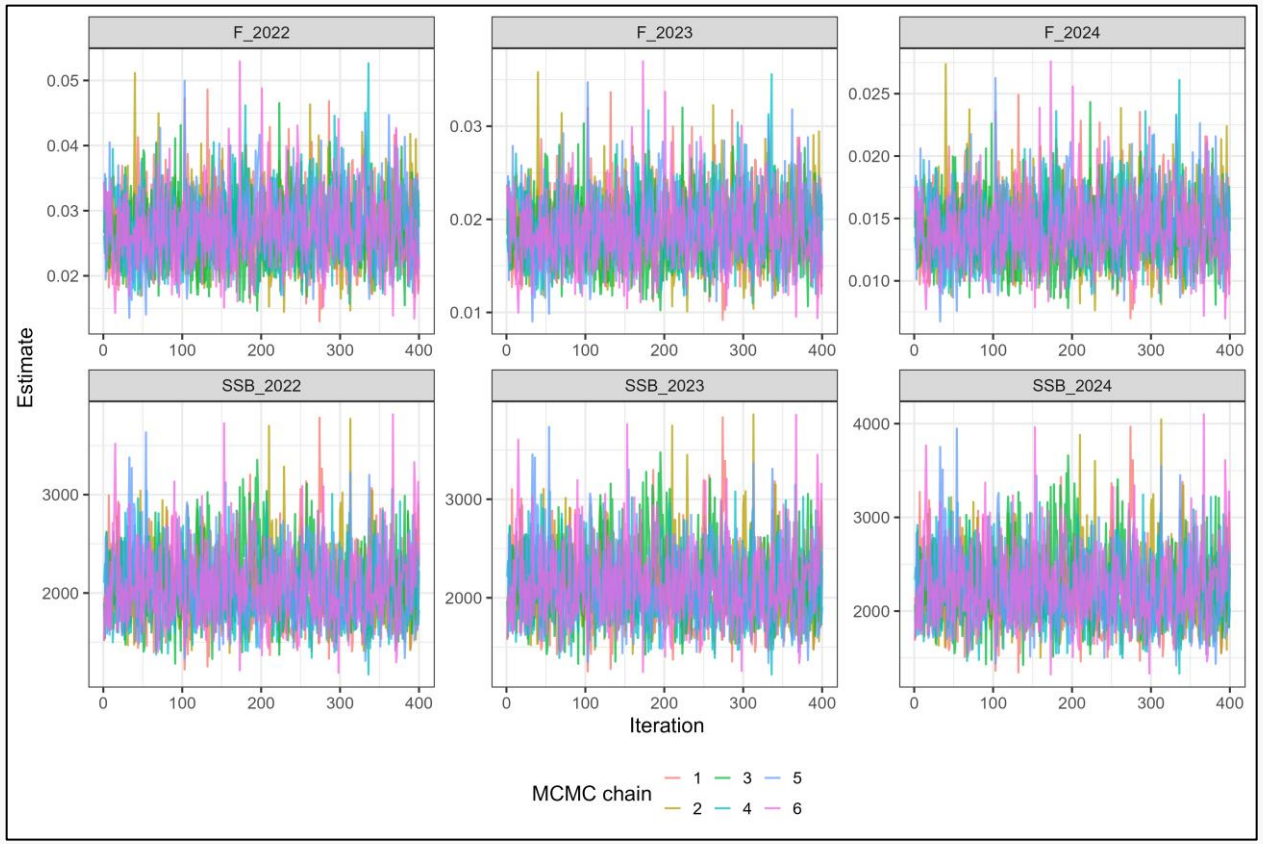
Parametric Bootstrap

- 1,000 bootstrapped datasets drawn from fitted values using input error distributions
- Model exhibited a measure of instability when fitting to the randomly generated data sets
  - 669 runs had a gradient >0.0001 (max. gradient 0.707)
  - 746 runs had at least one parameter on the bounds.
- KEYS base model estimates generally fell within the interquartile ranges of selected parameter estimates and derived quantities distributions

MCMC Analysis

Adapted from Figure 3.60

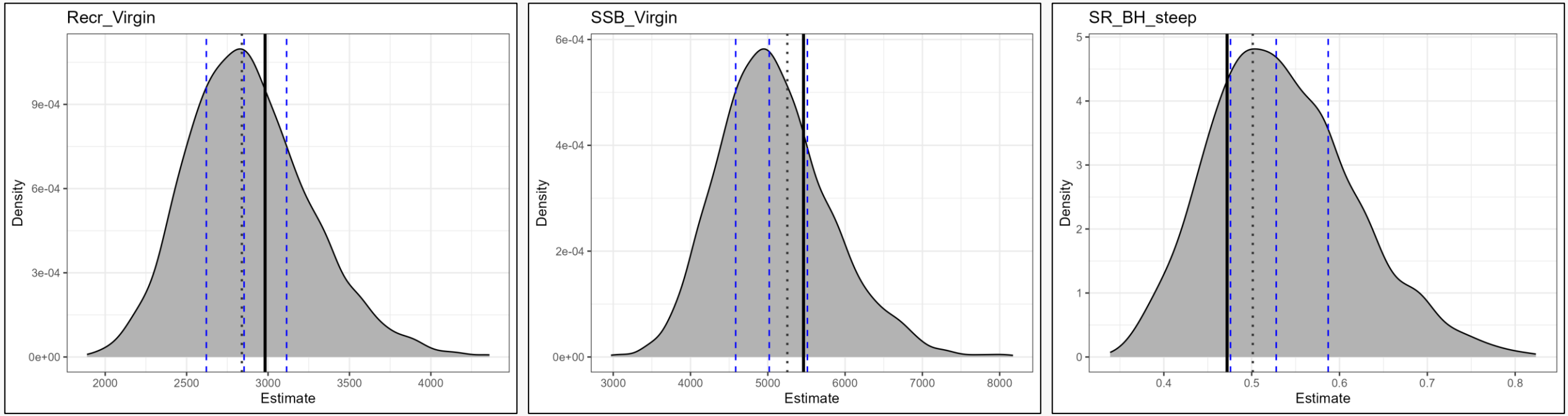




MCMC Analysis

Distributions largely supportive of profiles on R_0 (2,440 – 3,640) and *steepness* (0.4 – 0.6)

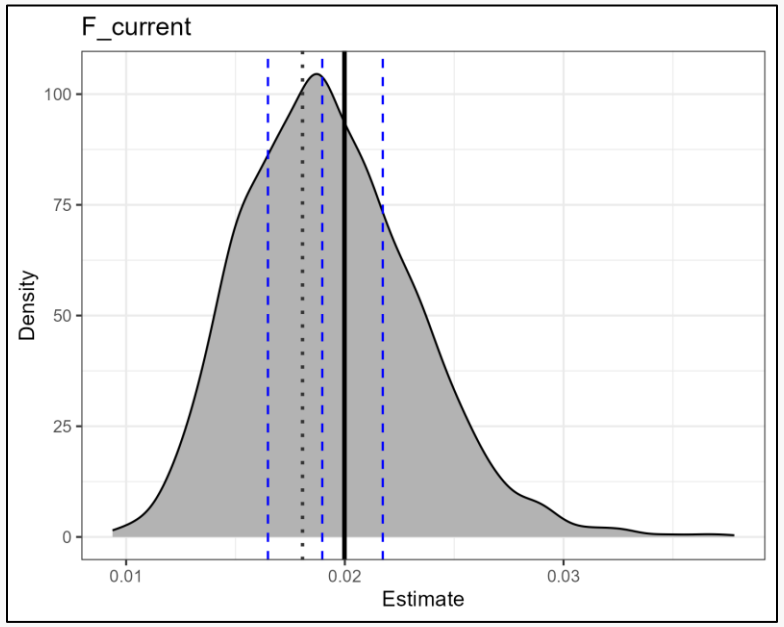
Adapted from Figure 3.61

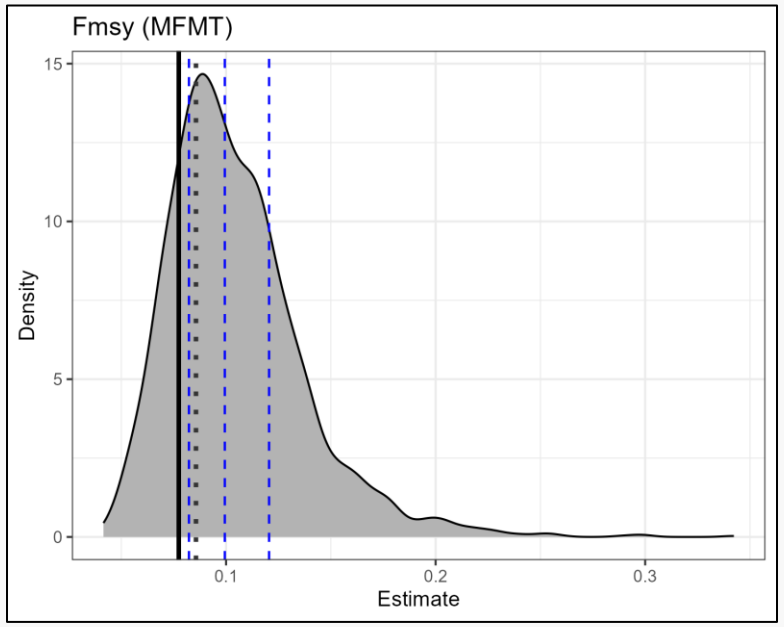


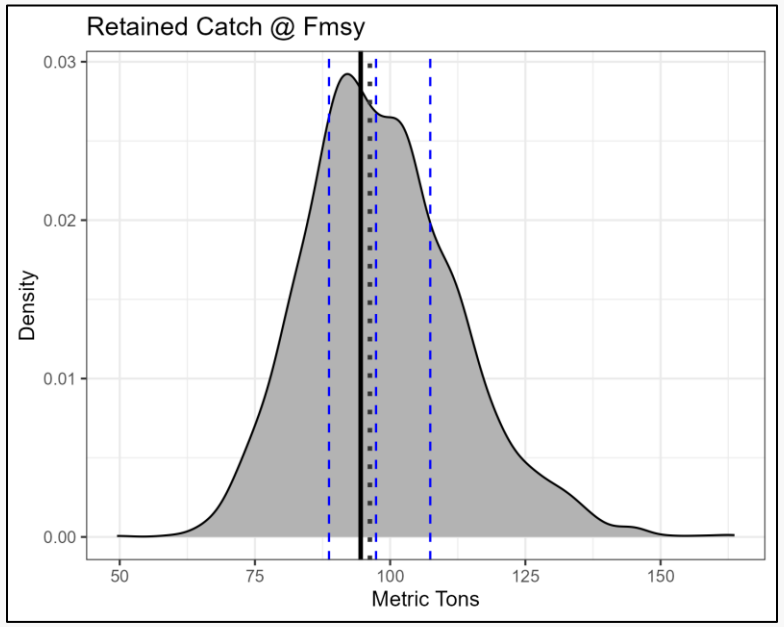
The blue dashed lines indicate the median and interquartile range, the black dotted line is the MLE from the MCMC 'proxy' model, and the solid black line is the MLE from the KEYS base model.

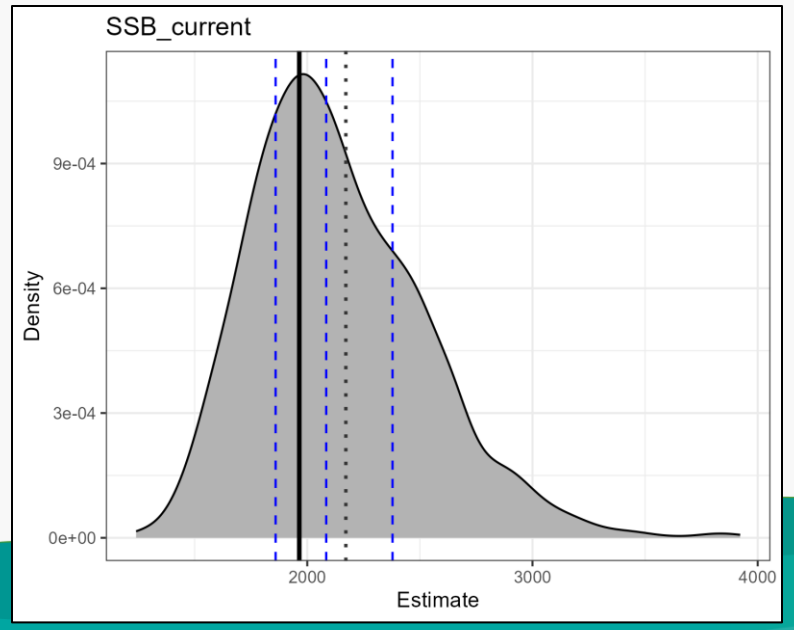
MCMC Analysis

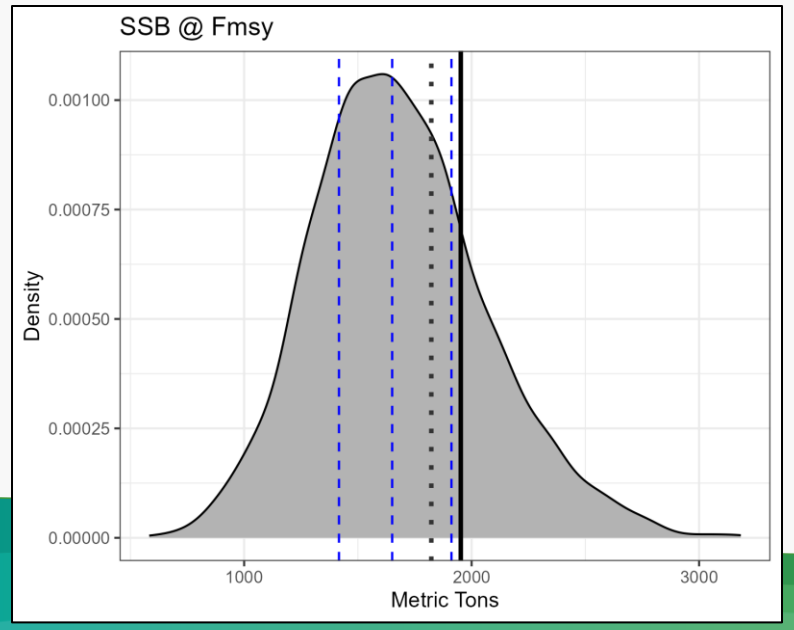
Adapted from Figure 3.62

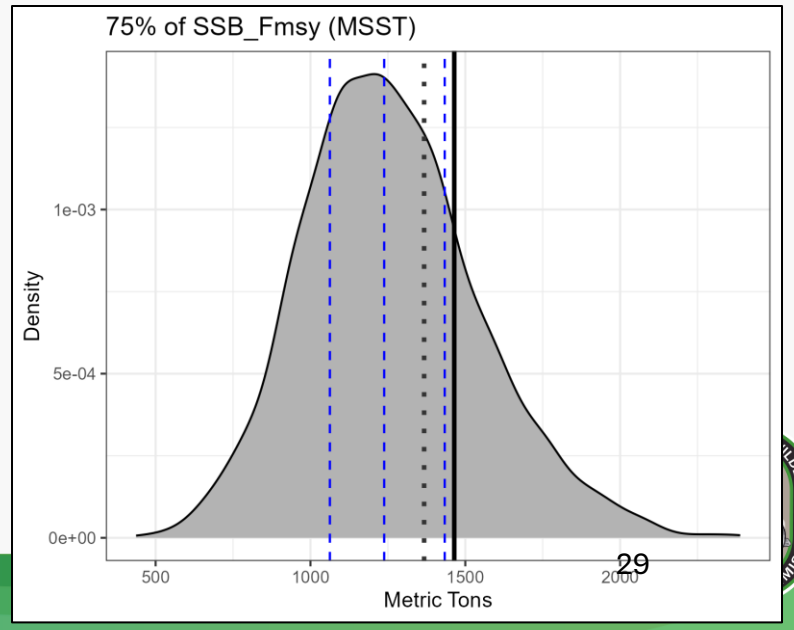




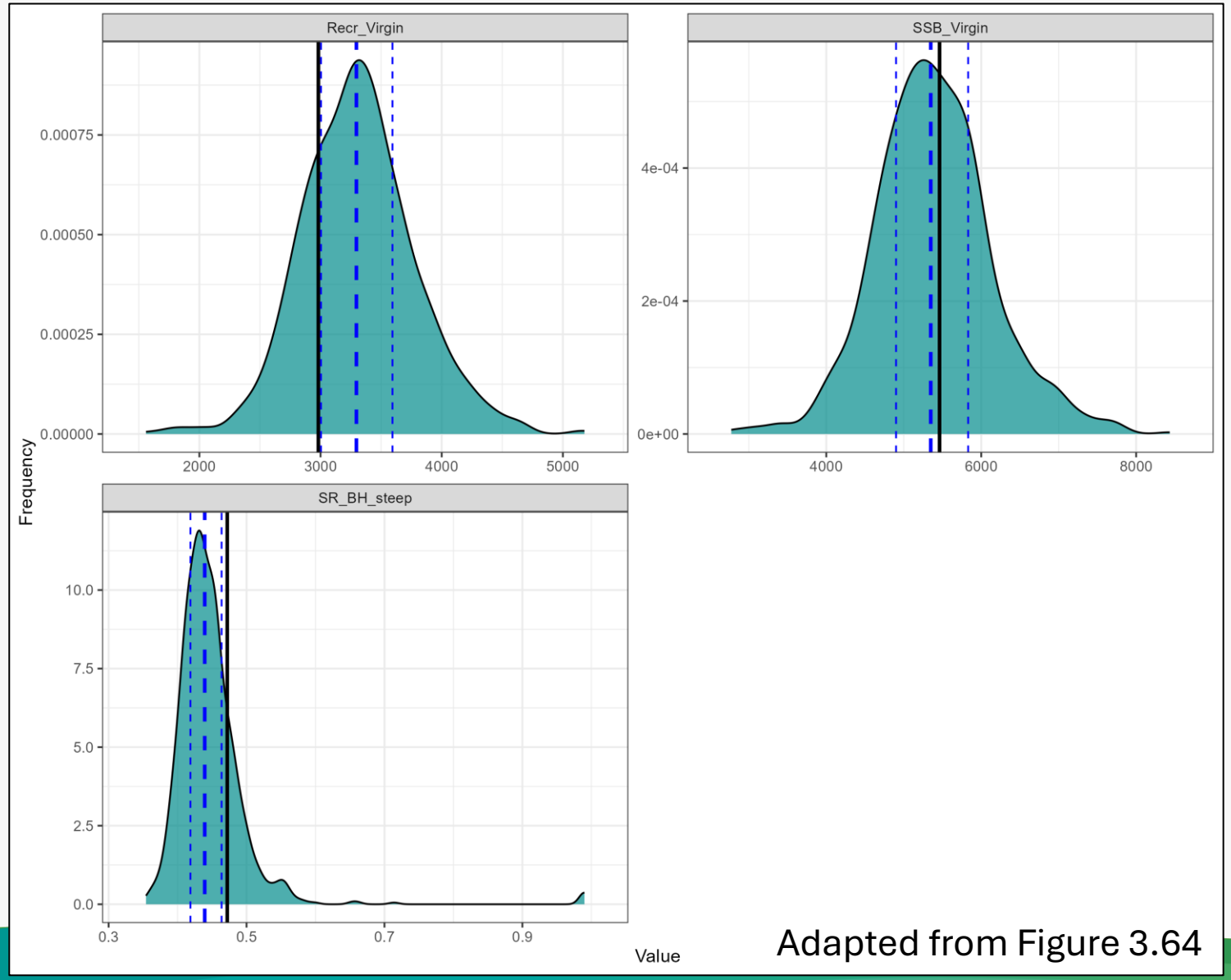








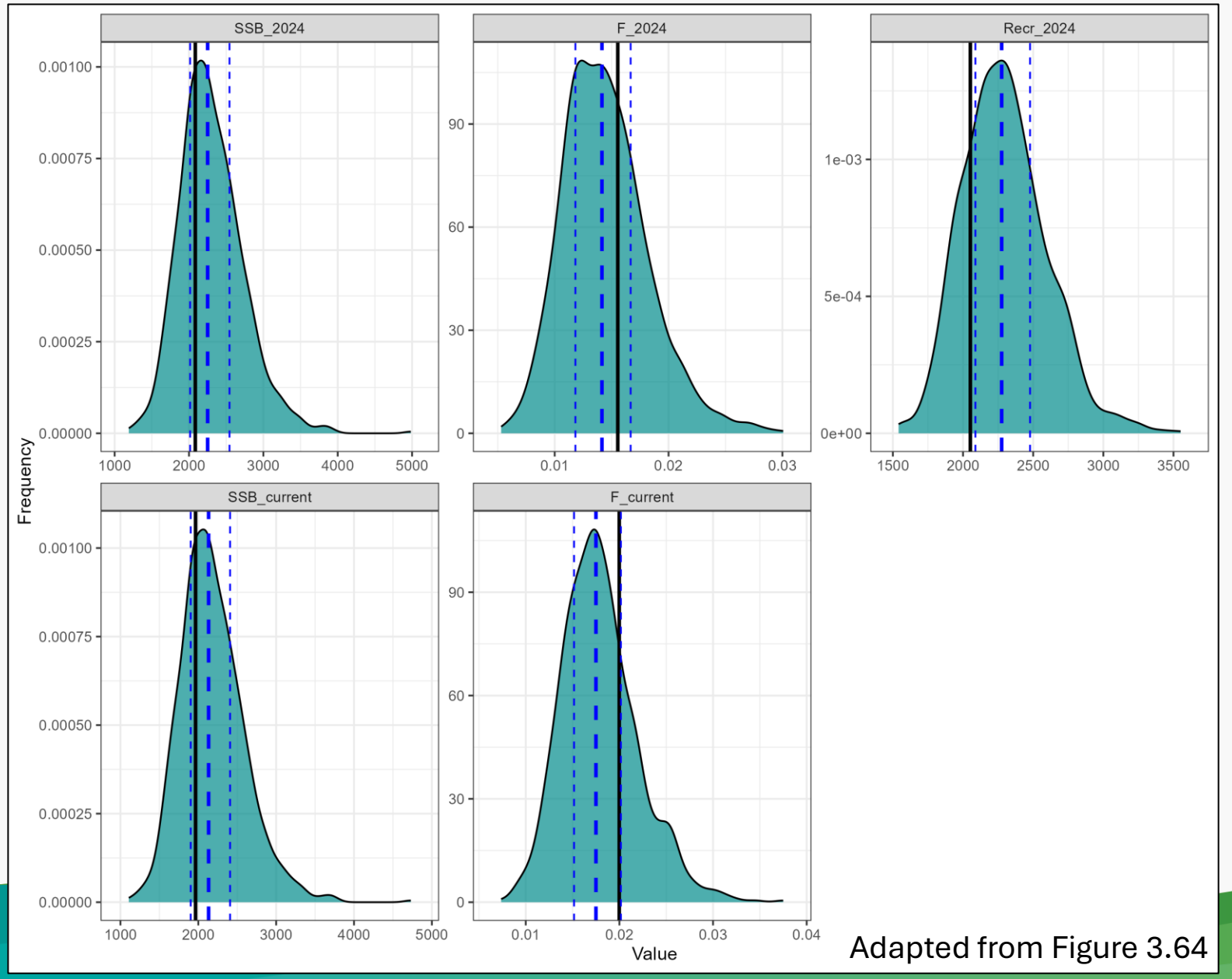
Bootstrap Analysis



Adapted from Figure 3.64

- Similar to MCMC posterior distributions
- Suggests larger population size (R_0 and SSB_0)
- *steepness* distribution more narrowed
- Supports parameter profiles

Bootstrap Analysis

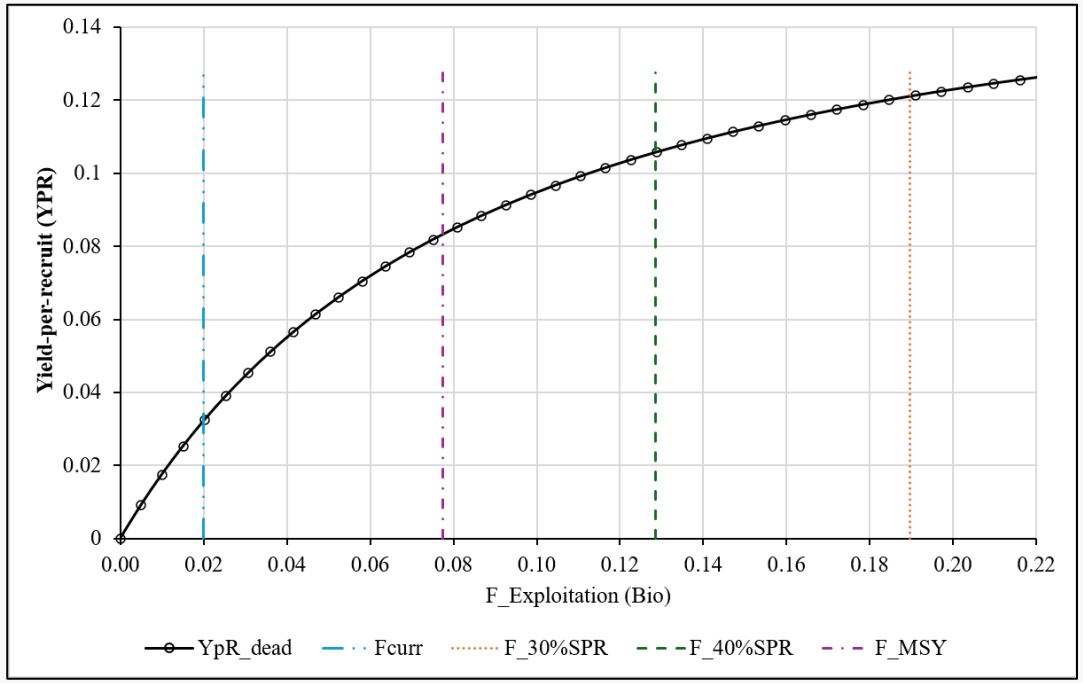


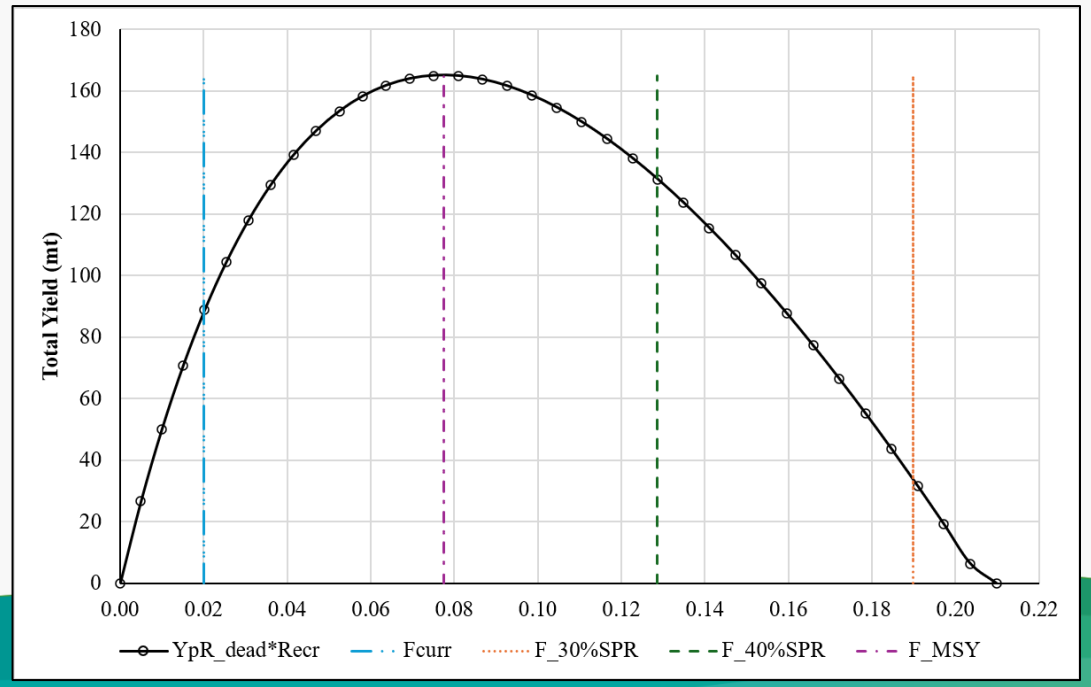
Adapted from Figure 3.64

SEDAR 94: Florida Hogfish

Stock Status Overview

Figure 3.58a,c

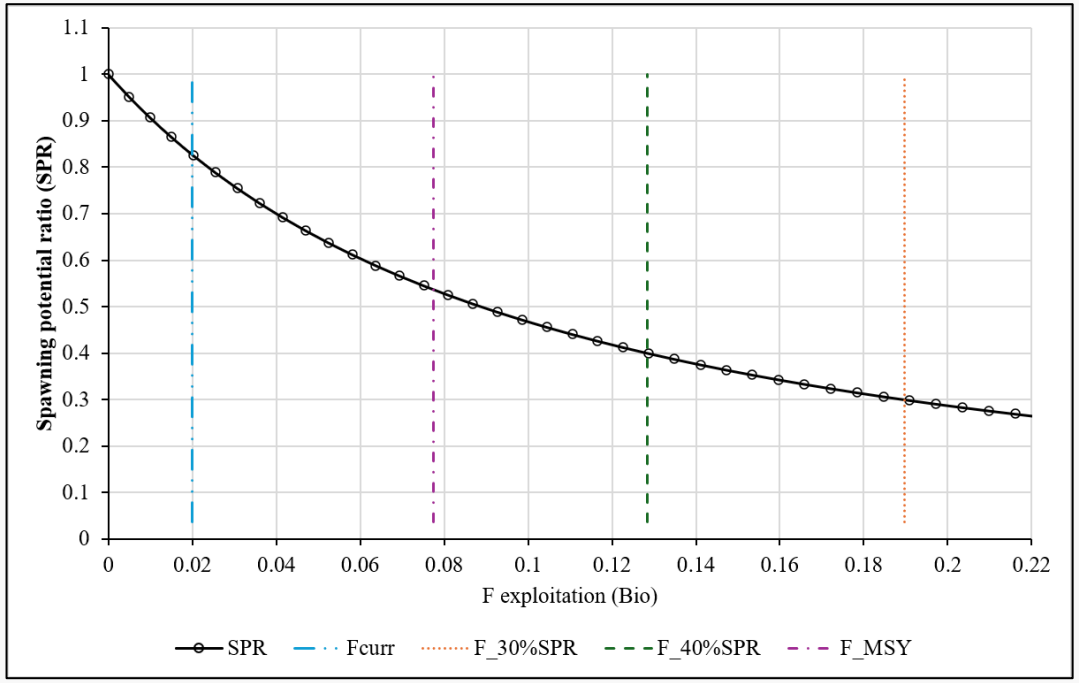


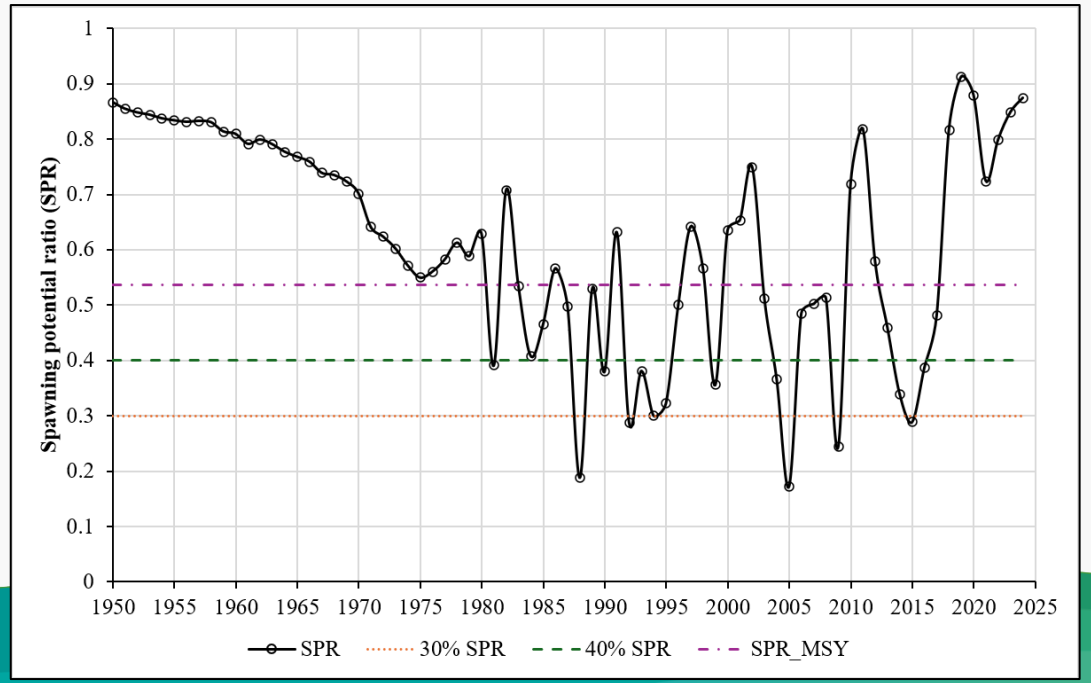


Per-recruit Analysis

- YPR highest at $F_{30\%SPR}$ but resulted in very low long-term total yields at 33.975 mt (74,902 lbs.)
  - Not sustainable under current assumptions of stock productivity
  - Yield estimate highly uncertain (CV = 2.5)
- YPR at $F_{40\%SPR}$ reduced by 13% but increased long-term total yield to 131.530 mt (289,974 lbs.)
- YPR at F_{MSY} reduced by 32% but long-term total yield increased to 165.068 mt (363,913 lbs.)

Figure 3.59





Spawing Potential Ratio (SPR)

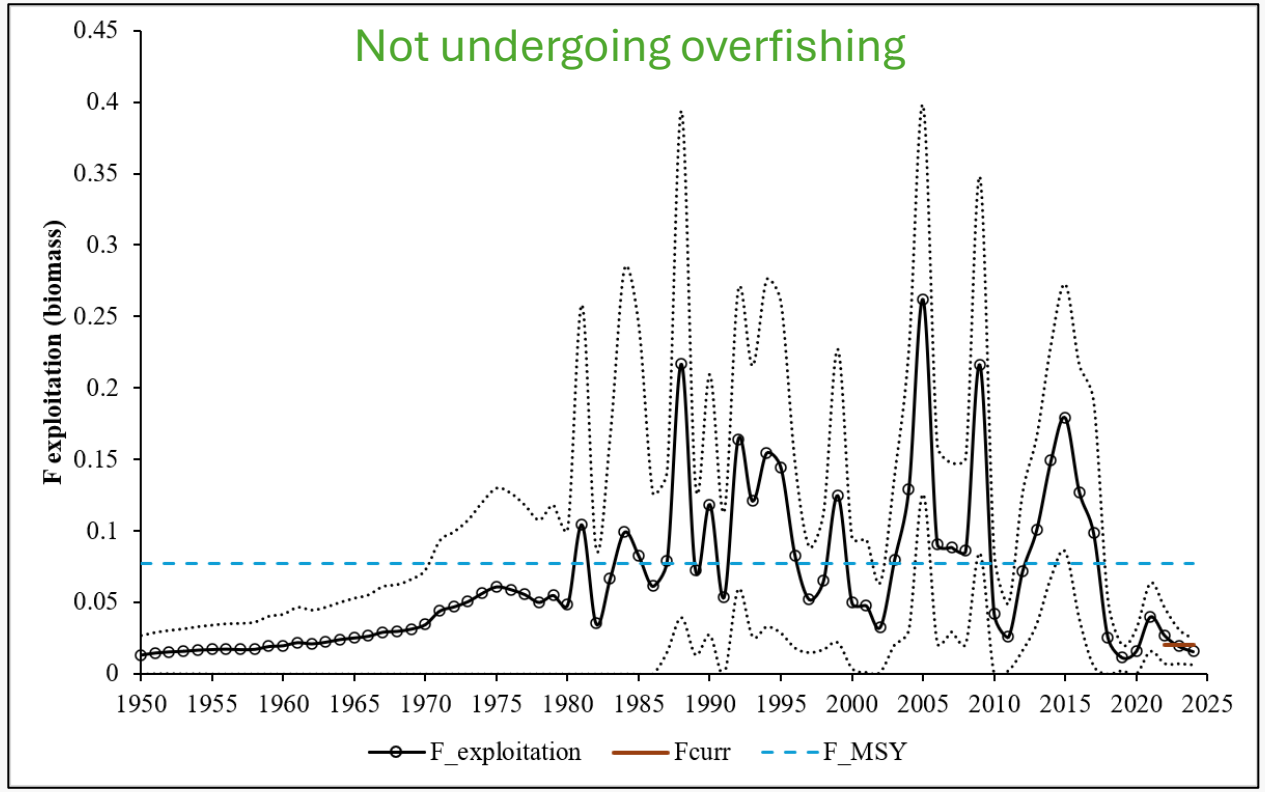
- $F_{current}$ = 0.020 SPR = 0.83
- F_{MSY} = 0.077 SPR = 0.54
- $F_{40\%SPR}$ = 0.128
- $F_{30\%SPR}$ = 0.190

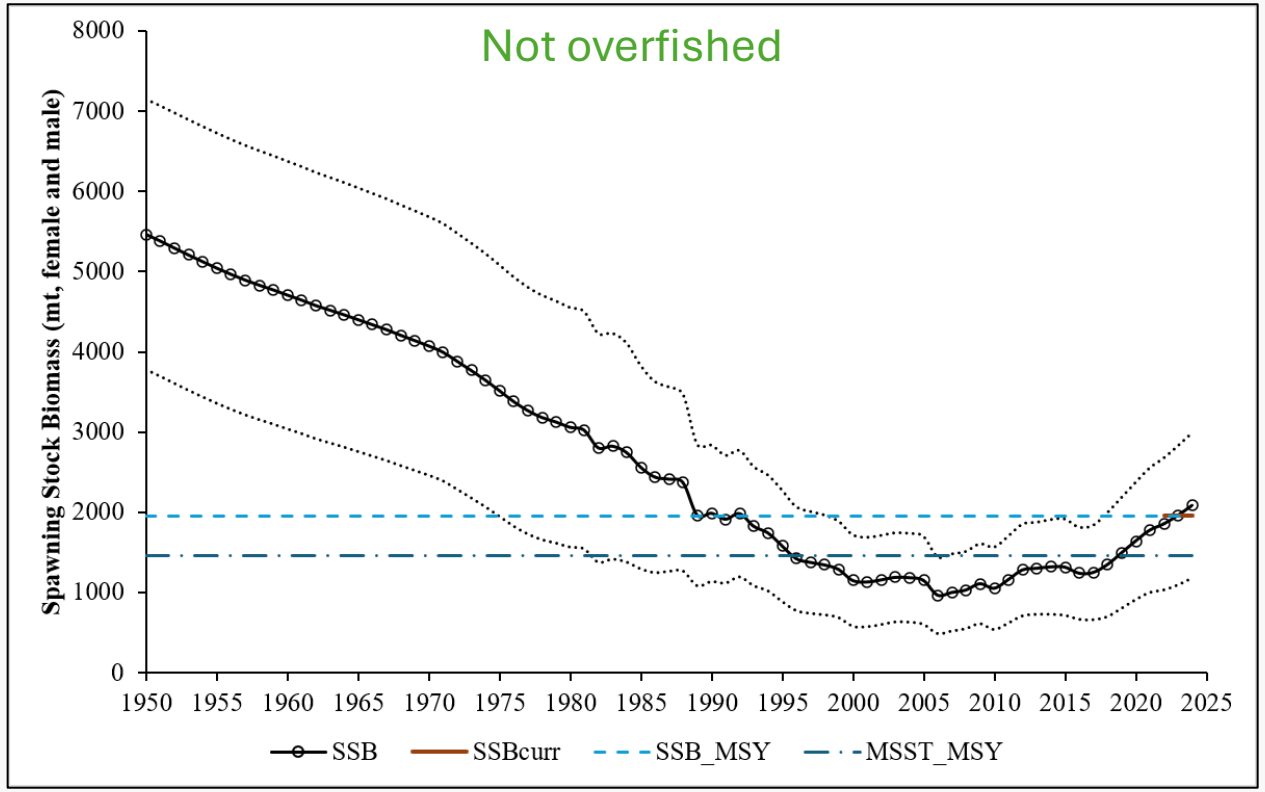
- Trend: declined, stabilized with variability, then increased again
  - 1995 – 2017: avg. SPR = 0.49
    - 1980 – 2017: avg. SPR = 0.47
  - 2018 – 2024: avg. SPR = 0.84

Stock Status

MSY-based reference values

Adapted from Figure 3.65





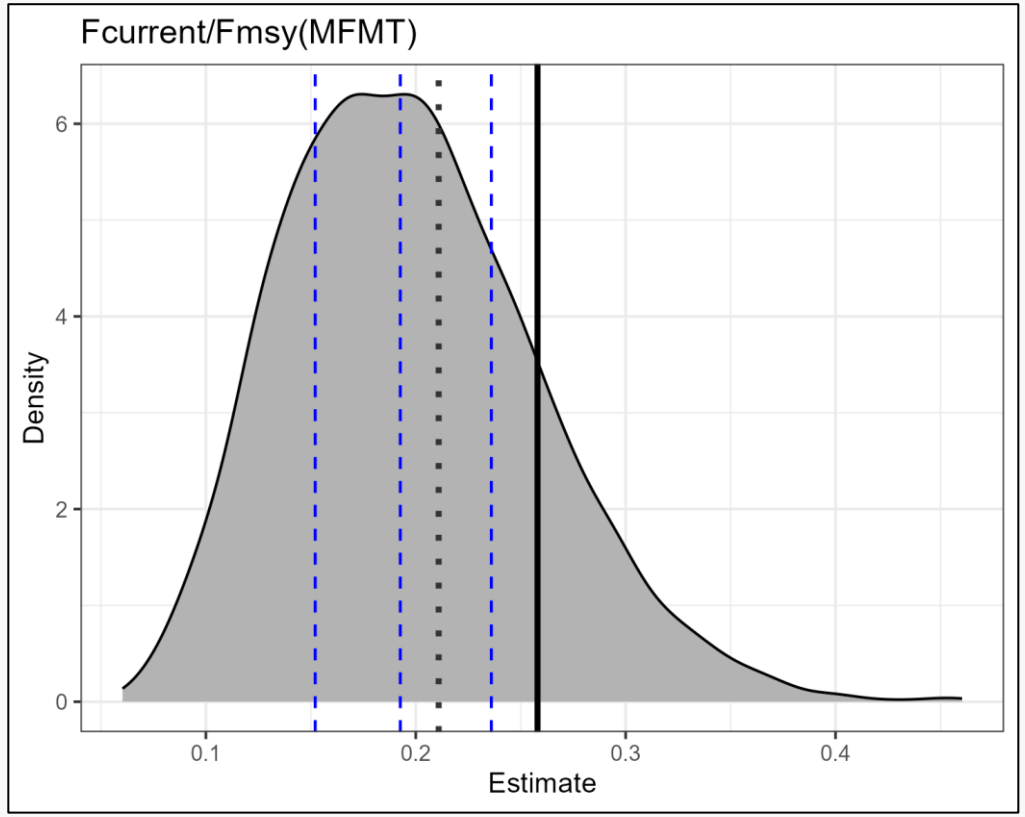
$F_{current}/F_{MSY}$ = 0.258

$SSB_{current}/MSST_{MSY}$ = 1.342

Stock Status

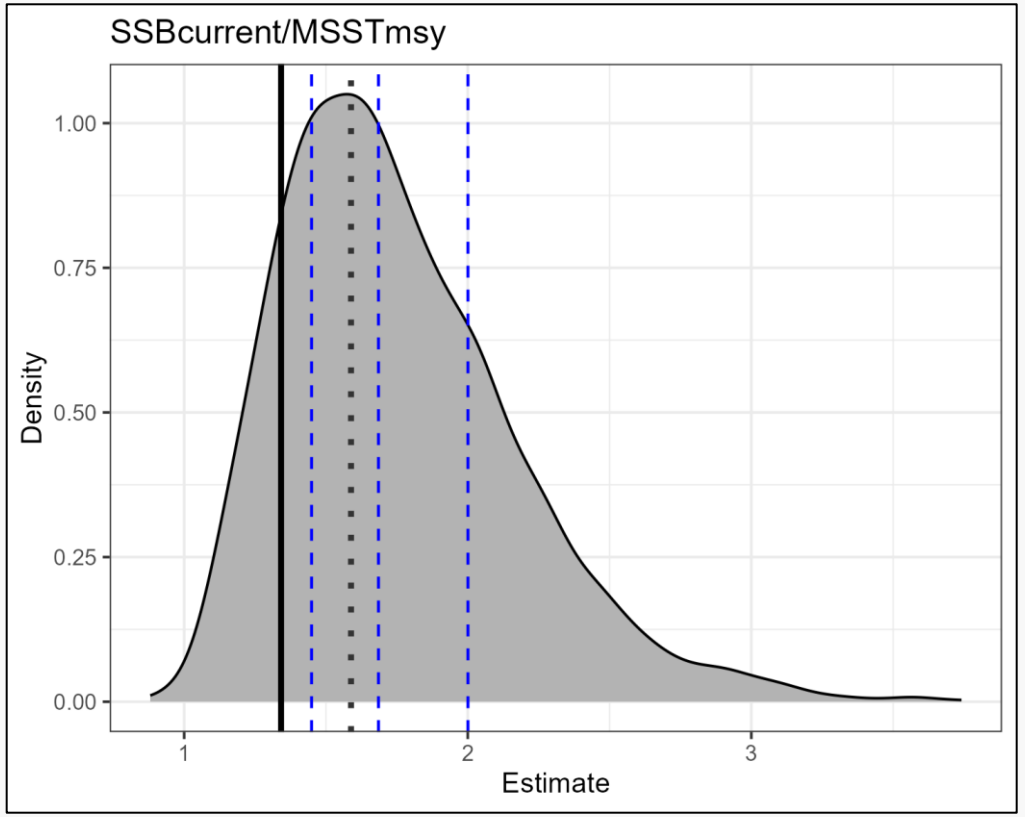
MSY-based reference values

Figure 3.67



$F_{current}/F_{MSY}$ median = 0.193

100% distribution < 1



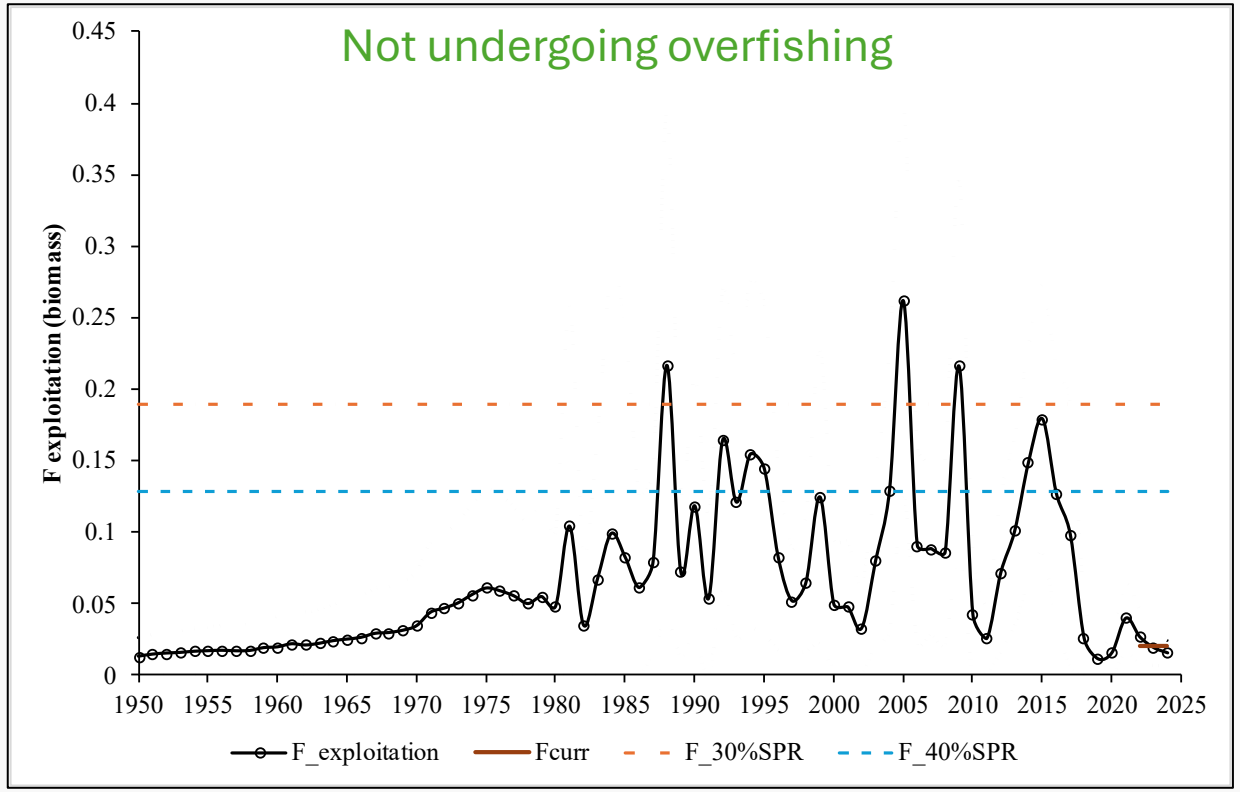
$SSB_{current}/MSST_{MSY}$ median = 1.342

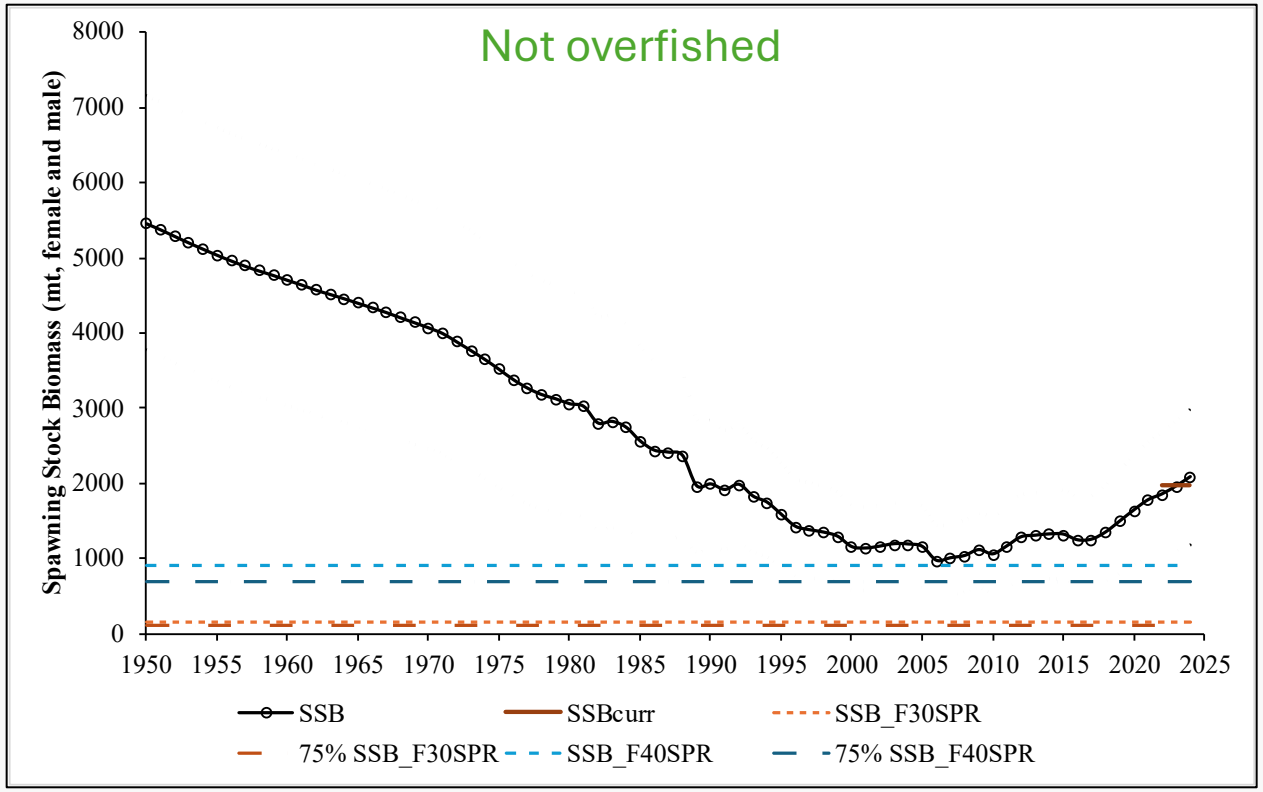
99% distribution > 1

Stock Status

SPR-based reference values

Adapted from Figure 3.66





$F_{current}/F_{40\%SPR} = 0.156$

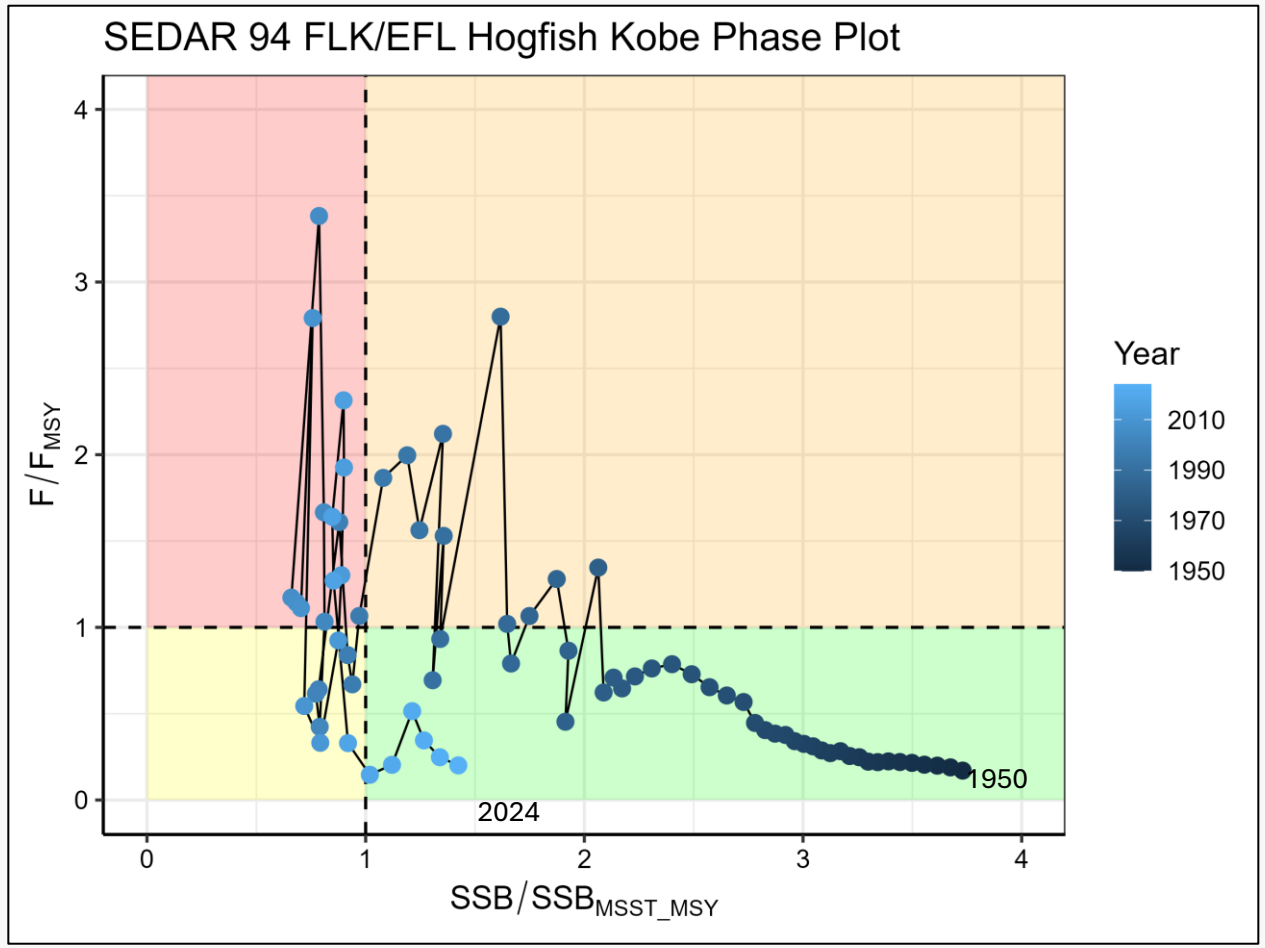
$SSB_{current}/SSB_{F40\%SPR} = 2.870$

$F_{current}/F_{30\%SPR} = 0.105$

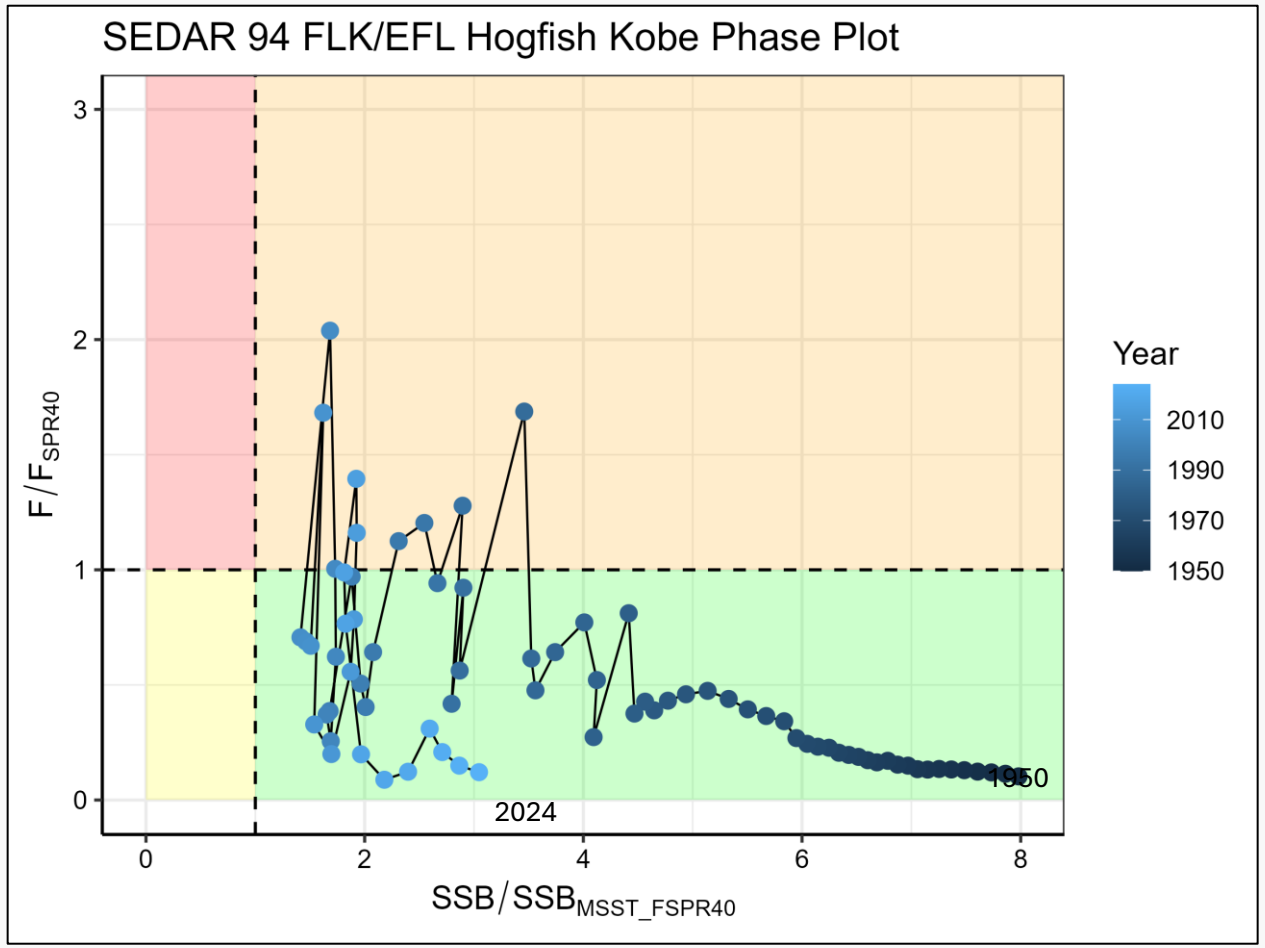
$SSB_{current}/SSB_{F30\%SPR} = 16.975$

Stock Status

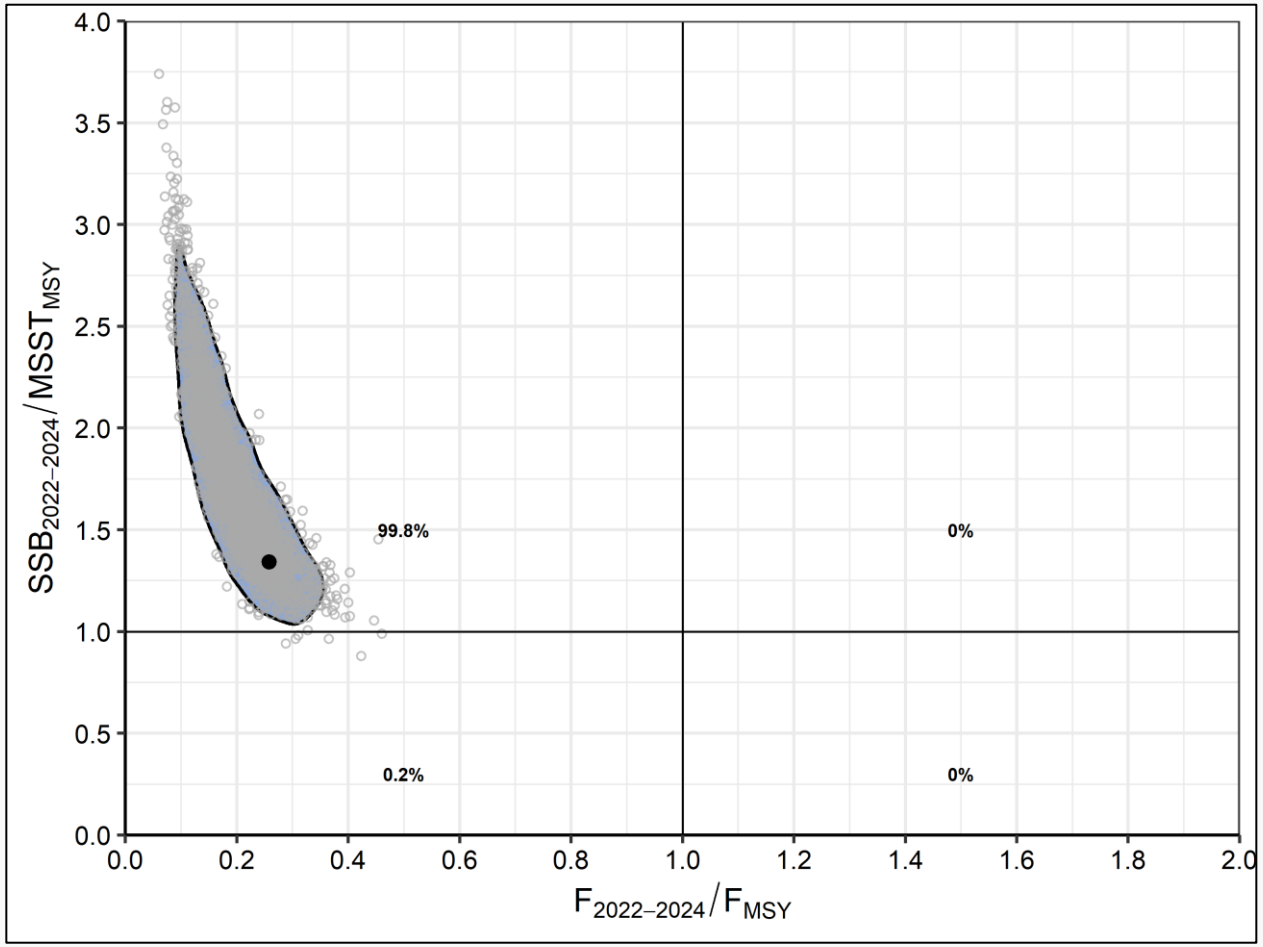
MSY-based reference values

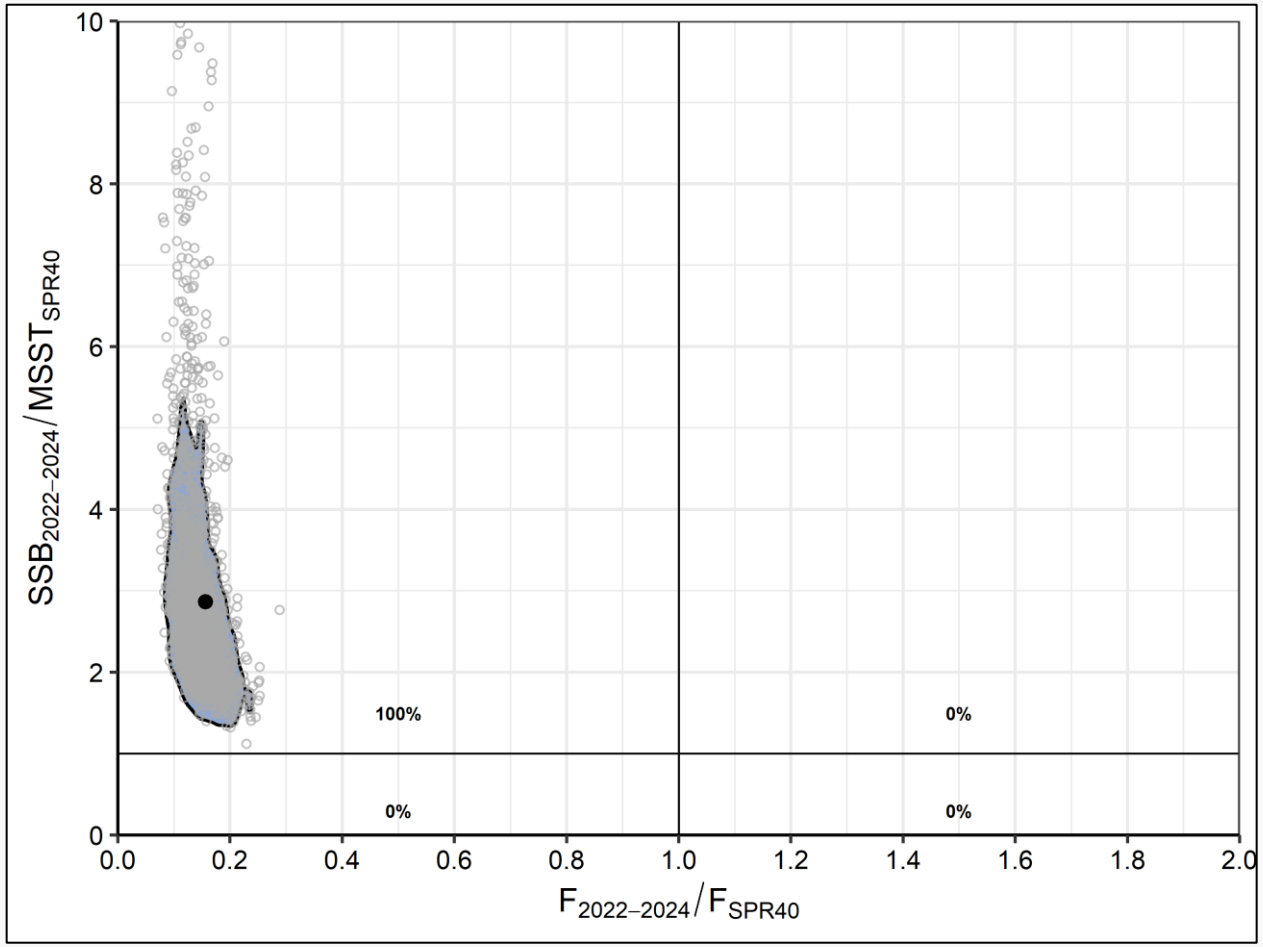


SPR-based reference values



Stock Status





Phase plots of the terminal estimates based on the MCMC ‘proxy’ model

Stock Status

Table 3.18

South Atlantic Fishery Management Council

Criteria	Definition	MSY	30% SPR	40% SPR
MSY	The retained yield at F_{MSY} or $F_{SPRproxy}$	94.552 mt (208,451 lbs.)	17.249 mt (38,027 lbs.)	71.100 mt (156,709 lbs.)
$F_{MSY\ or\ proxy}$	The fishing mortality rate associated with MSY or SPR proxy	0.077 yr^{-1}	0.190 yr^{-1}	0.128 yr^{-1}
MFMT (Maximum Fishing Mortality Threshold)	$F_{MSY\ or\ SPR\ proxy}$	0.077 yr^{-1}	0.190 yr^{-1}	0.128 yr^{-1}
$F_{current}$ (recent average fishing mortality rate)	The geometric mean of F exploitation for 2022 – 2024		0.020 yr^{-1}	
$SSB_{MSY\ or\ SPRproxy}$	The estimated spawning stock biomass associated with F_{MSY} or $F_{SPRproxy}$	1,952.4 mt (4,304,305 lbs.)	154.312 mt (340,300 lbs.)	912.573 mt (2,011,879 lbs.)
MSST (Minimum Stock Size Threshold)	$0.75*SSB_{MSY\ or\ SPRproxy}$	1,464.3 mt (3,228,229 lbs.)	115.734 mt (255,150 lbs.)	684.43 mt (1,508,909 lbs.)
$SSB_{current}$ (recent average of SSB)	The geometric mean of SSB for 2022 – 2024		1,964.579 mt (4,331,156 lbs.)	

SEDAR 94: Florida Hogfish

Bridge Building

Continuity Models

TOR 2.2

- *"Provide a continuity model consistent with the prior benchmark (SEDAR 37) and update (SEDAR 37U) assessment configurations,* ***if one exists****, updated to include the most recent observations.* ***Alternative approaches to a strict continuity run that distinguish between model, population, and input data influences on findings, may be considered."***

- *"Provide additional continuity models which update these prior assessment's configurations and terminal years with ~~MRIP-FES~~ (SRFS) landings and discards."*

- **Strict continuity models largely unreproducible due to changes in data streams**
  - 1) Updated the SEDAR 37 FLK/EFL base model to the configuration of the SEDAR 94 KEYS base model ("S37data_S94config" scenario)
  - 2) Updated the SEDAR 37 FLK/EFL base model by replacing the MRFSS/MRIP ad-hoc recreational landings by gear with the Full SRFS back-calculated landings by gear ("S37_SRFS" scenario)

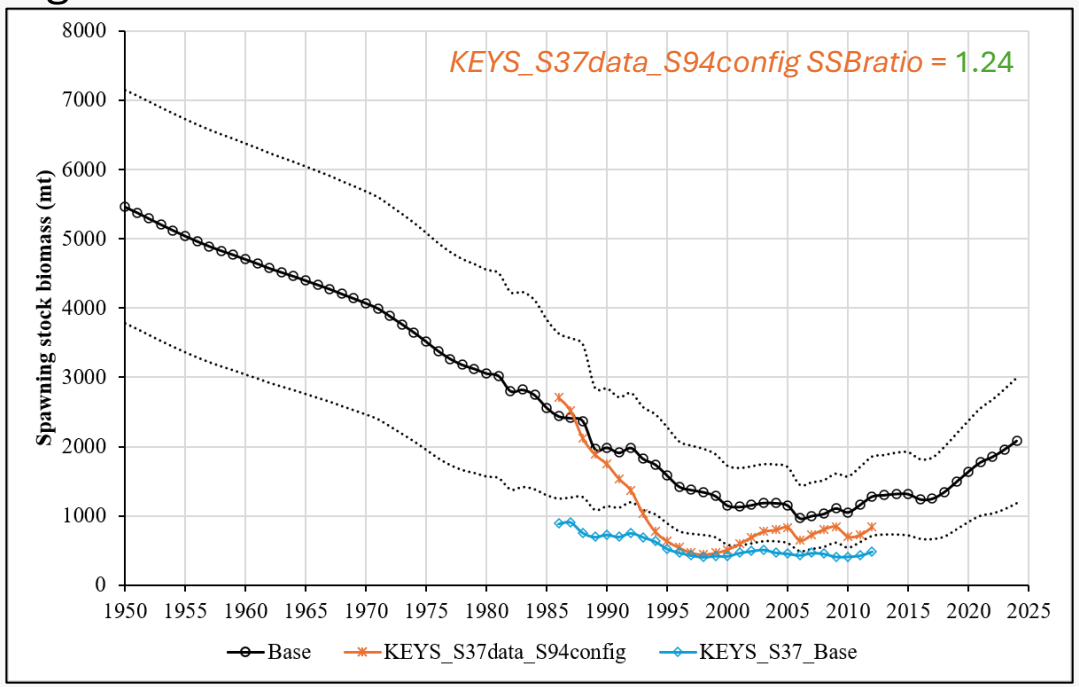
Continuity Models

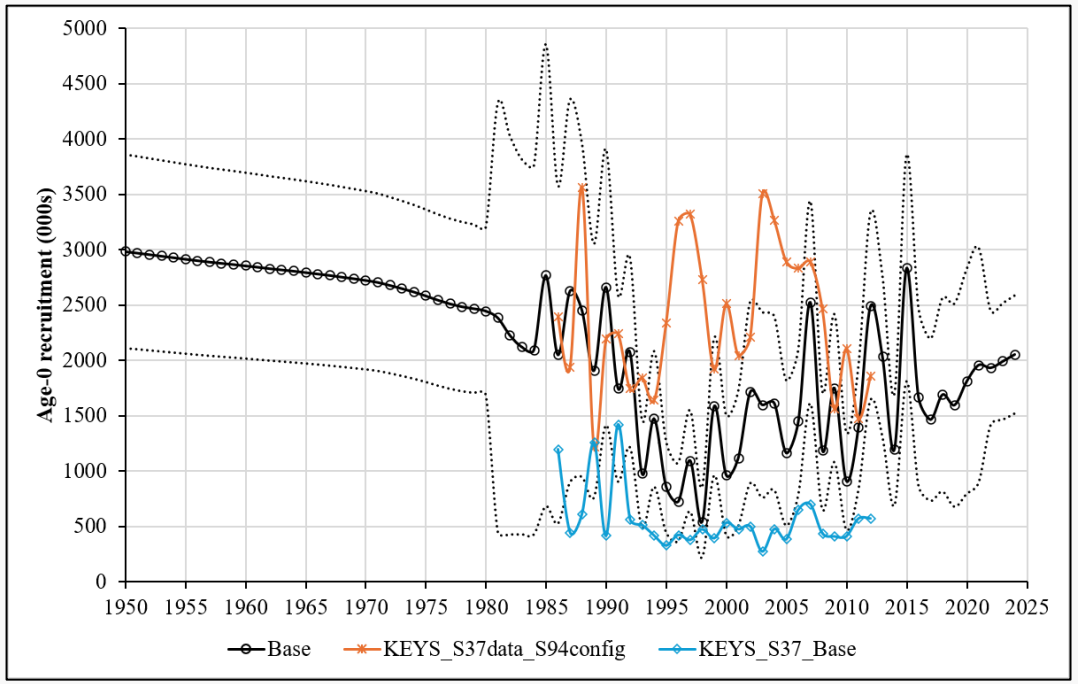
Objective: SEDAR 37 base model data incorporating SEDAR 94 configuration

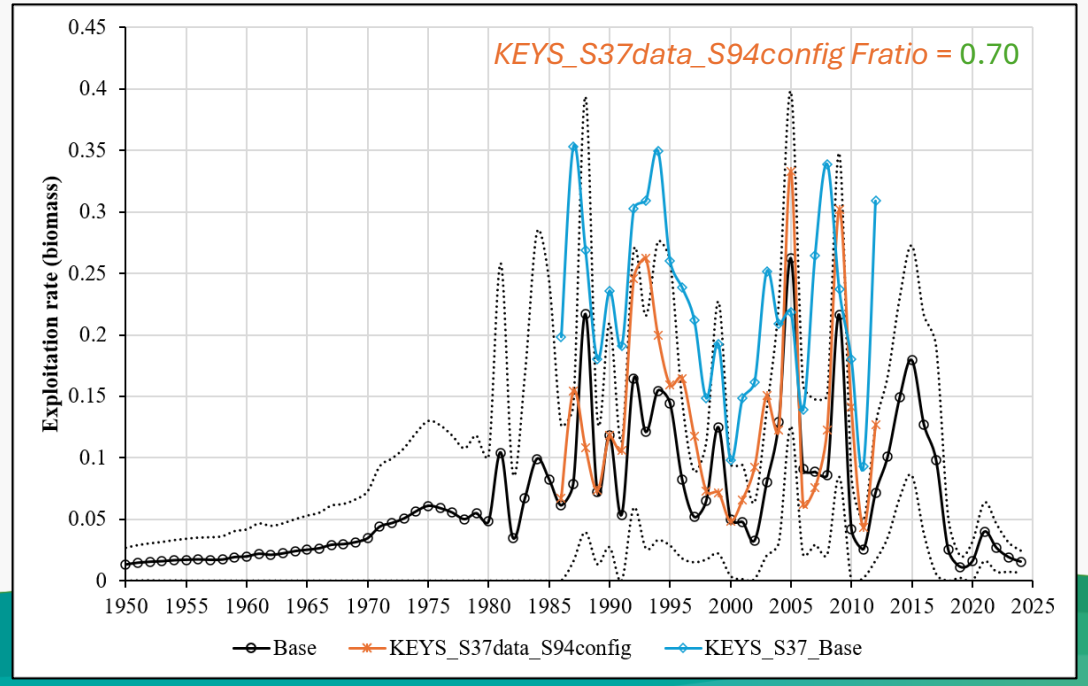
Key Configuration Changes to S37:

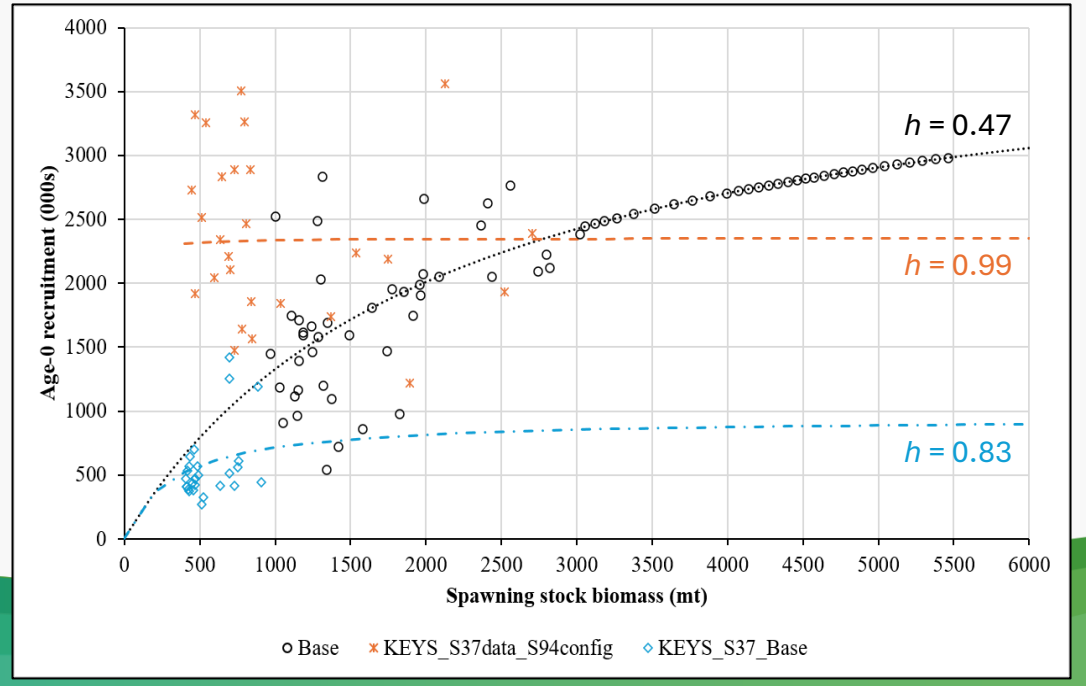
- SS model version 3.24 to 3.30
- Combine fishery fleets
  - 3 Comm fleets into 1 Comm Fleet
  - 2 Rec fleets into 1 Rec Fleet
  - Kept Comm log SEs at 0.1 and Rec log SEs at 0.4
- Add regulatory time block in 1995
- Indices
  - Keep RVC FL Keys and RVC Dry Tortugas
  - Remove all FD Indices
- Selectivity
  - Time varying with regulatory block
  - Fleets/surveys double normal function
- Applied stock-specific life history values (natural mortality, growth, maturity, and hermaphroditism) from S94
  - Estimated growth
  - Utilized 5 platoons
- Fixed *steepness* at 0.99
  - Estimated *sigmaR*
- Number of ages from 20 to 16
- Length bins from 2-90cm to 2-86cm
- Applied Dirichlet weighting on length composition data

Figure 3.68

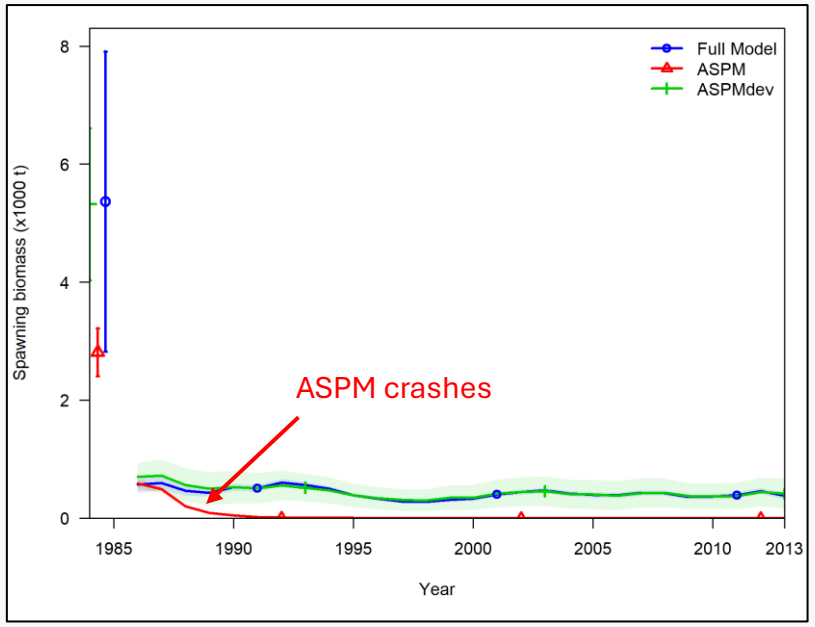

KEYS_S37data_S94config SSBratio = 1.24
Spawning stock biomass (mt)
Base
KEYS_S37data_S94config
KEYS_S37_Base

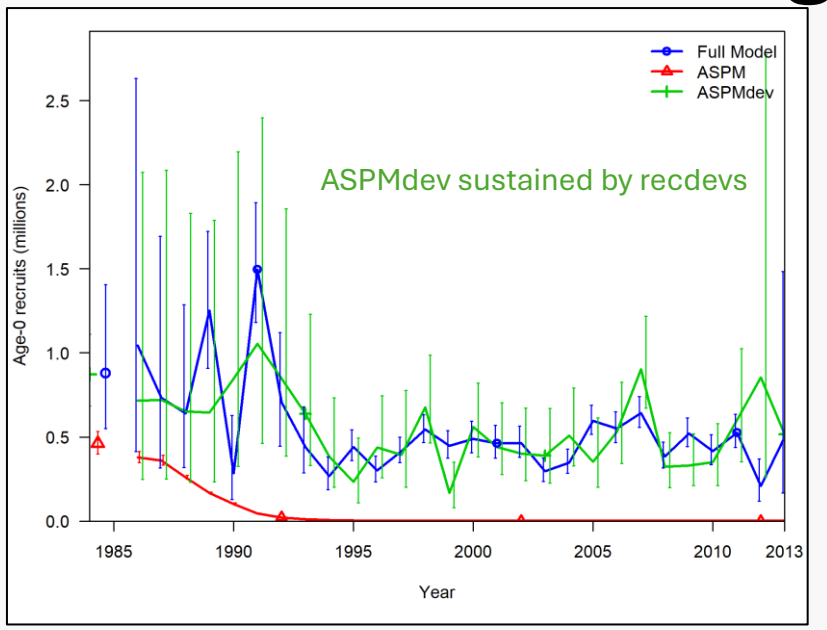

Age-0 recruitment (000s)
Base
KEYS_S37data_S94config
KEYS_S37_Base

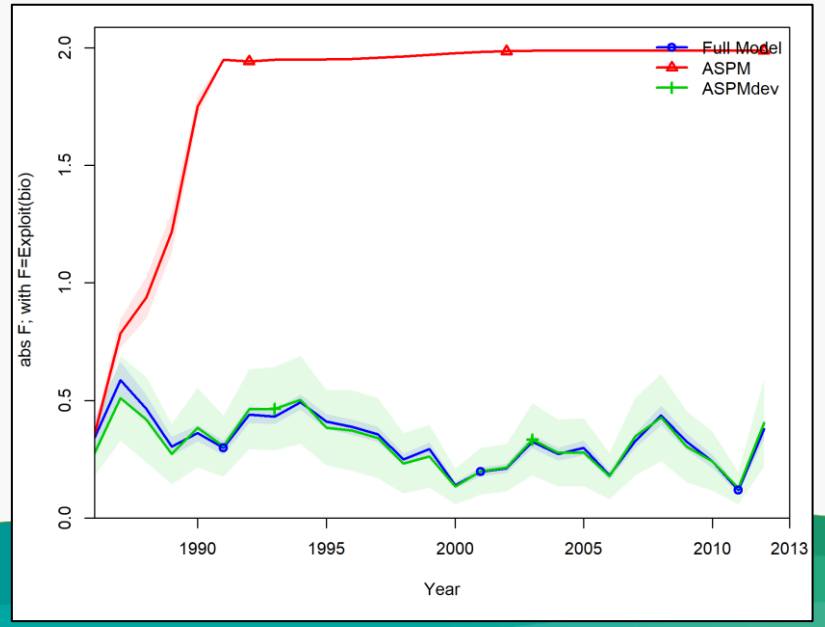

KEYS_S37data_S94config Fratio = 0.70
Exploitation rate (biomass)
Base
KEYS_S37data_S94config
KEYS_S37_Base


h = 0.47
h = 0.99
h = 0.83
Age-0 recruitment (000s)
Spawning stock biomass (mt)
Base
KEYS_S37data_S94config
KEYS_S37_Base

SEDAR 37 FLK/EFL Base Model: ASPM Diagnostics







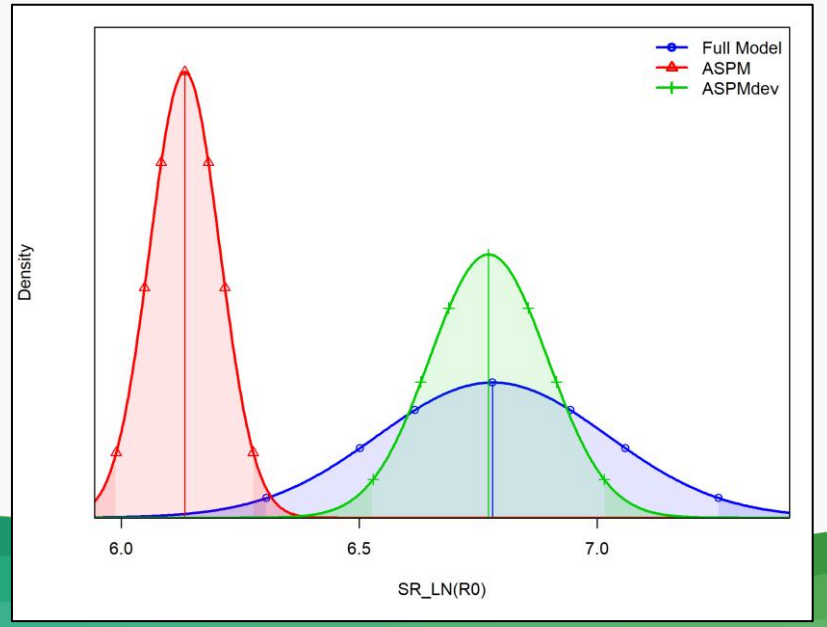
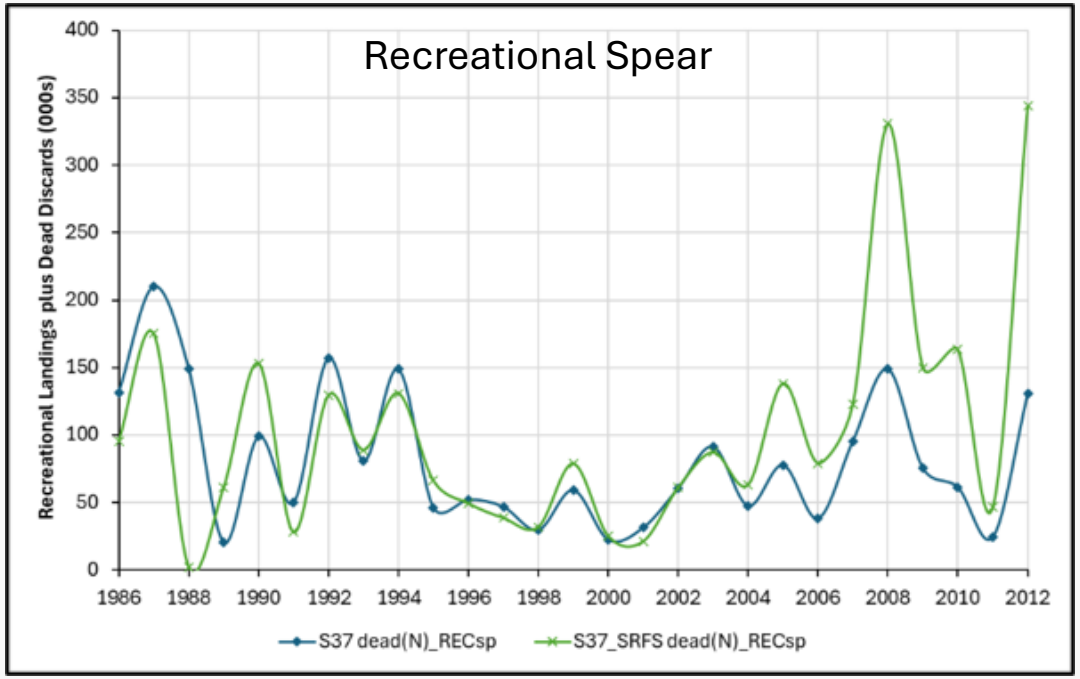
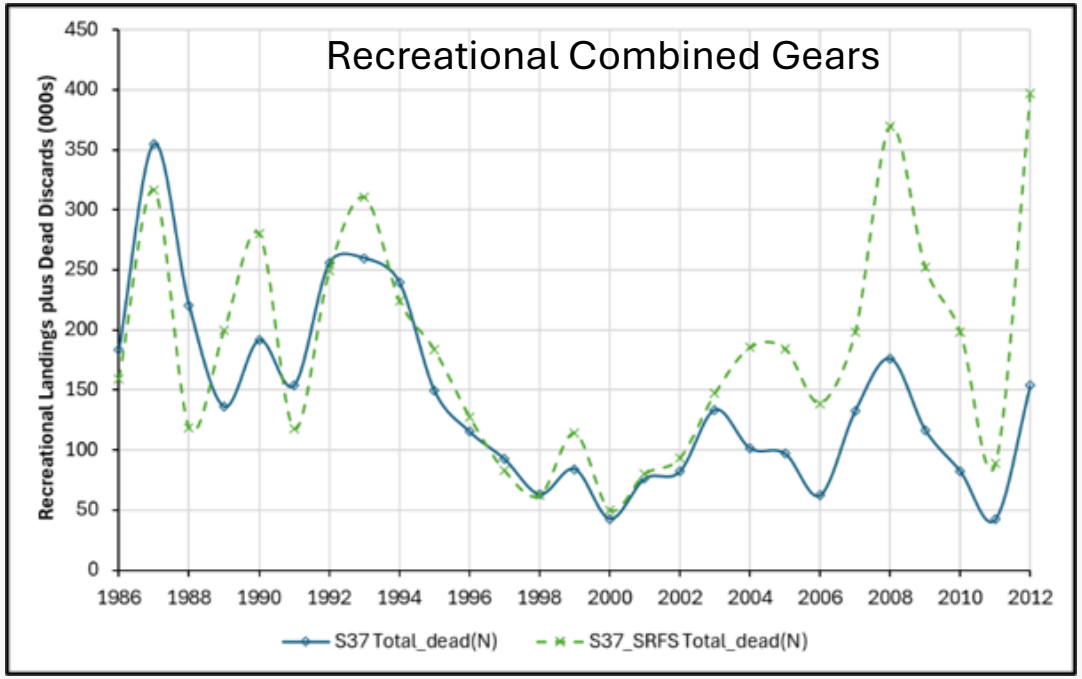
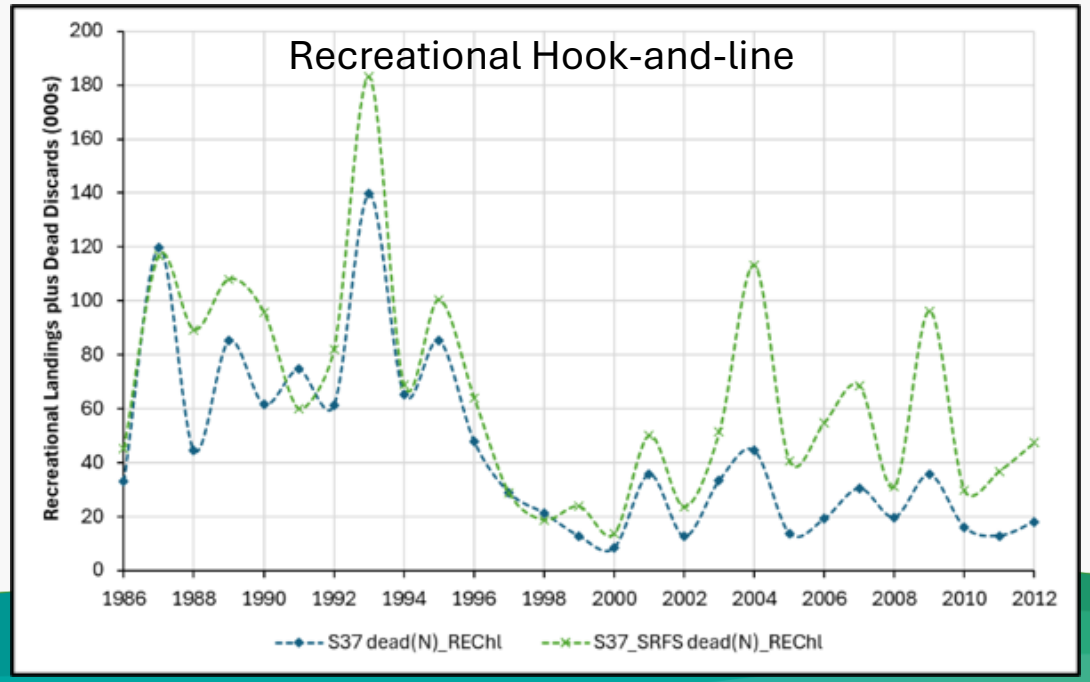


Figure 3.69



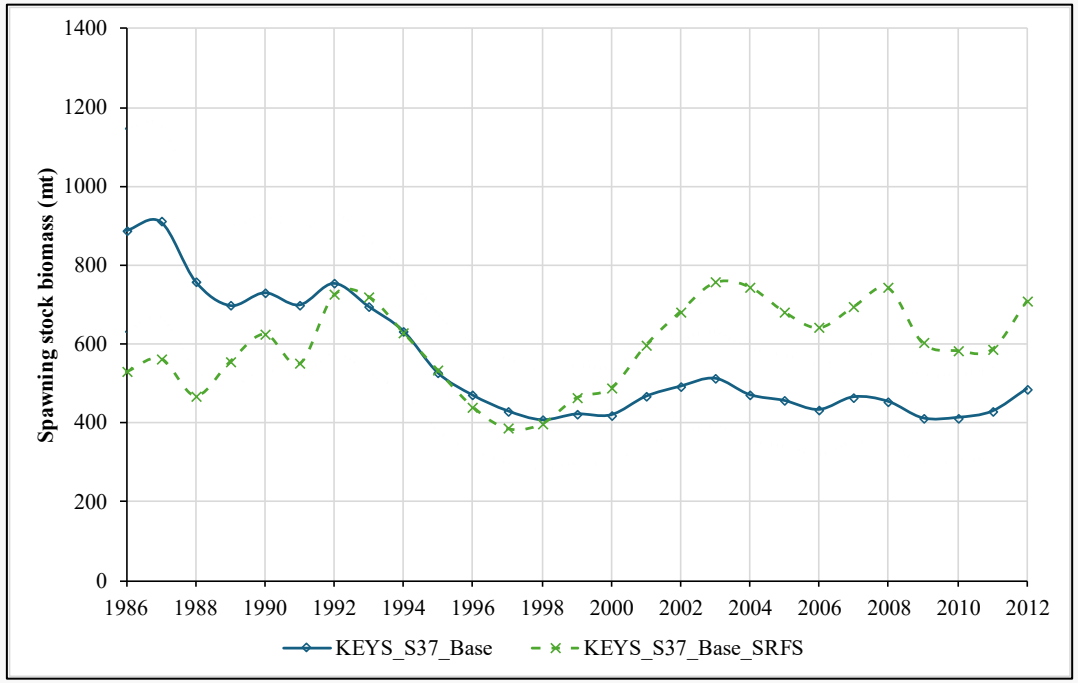


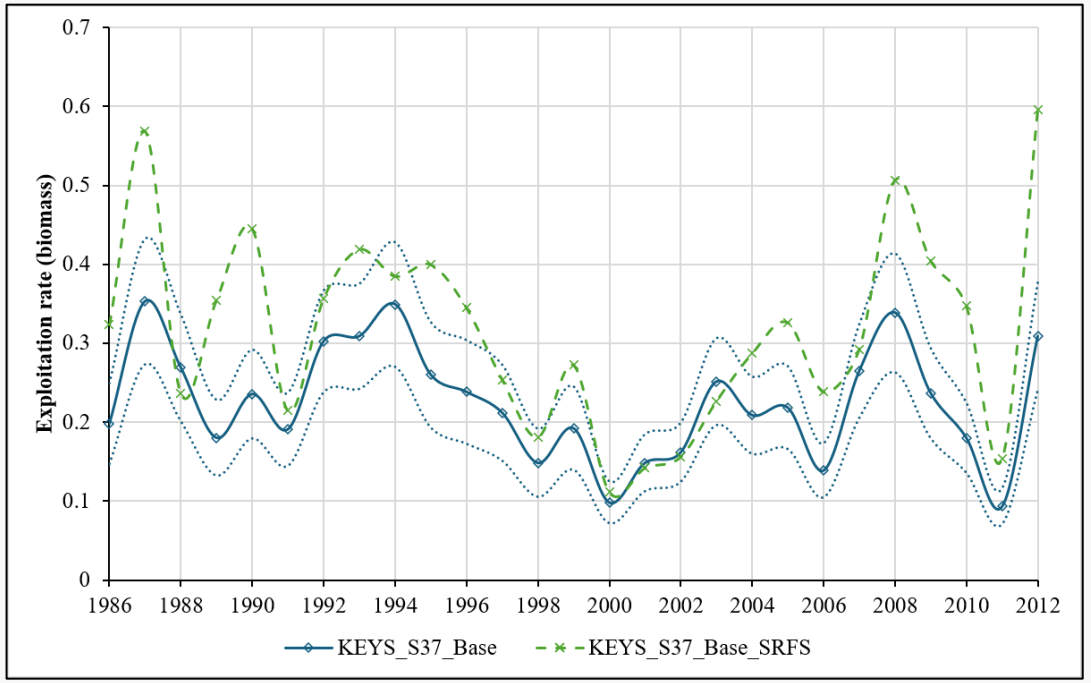


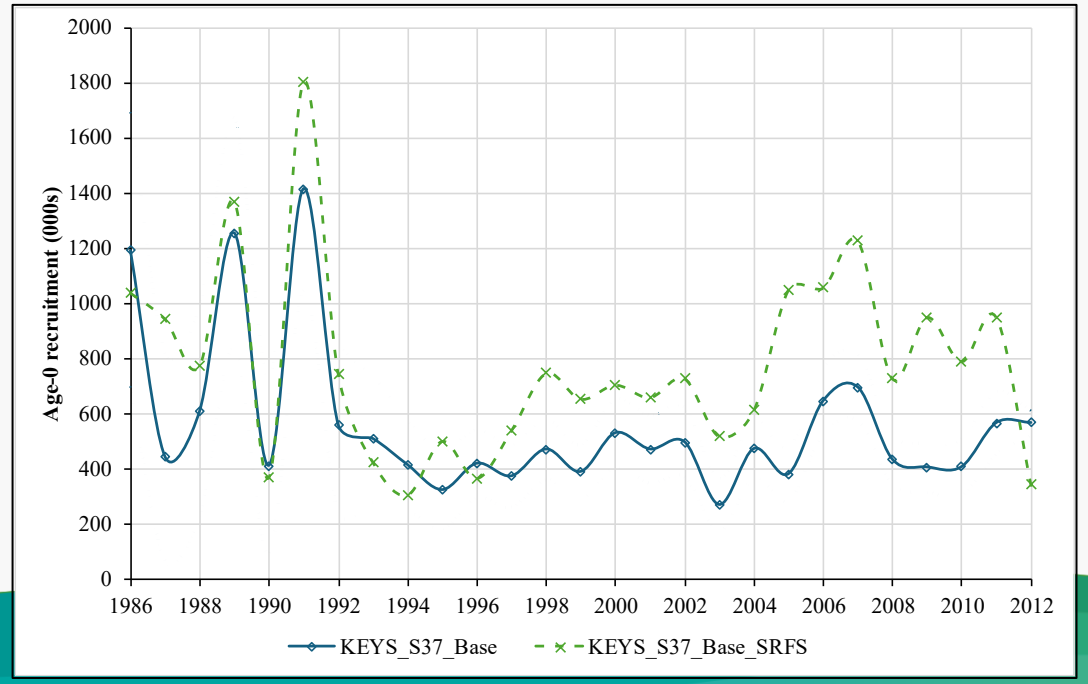
"SEDAR_37_SRFS" continuity model

- MRFSS/MRIP ad-hoc changed to Full SRFS back-calculated timeseries
- Magnitudes similar with more drastic changes occurring from 2004 onwards (i.e., beginning of MRIP)
  - SRFS back-calculated is a scalar reduction of MRIP private

Figure 3.70







- Populations estimates not meaningfully different
  - Often within S37 Base uncertainty bounds or follow the upper bound
- Exploitation follows the new landings trend
  - Increases to recruitment and SSB scales

Thank You!